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A New Concept—Using Chemicals
for Soil Structure Improvement

Water and Timber Management
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Reviews: They are Your Woods!
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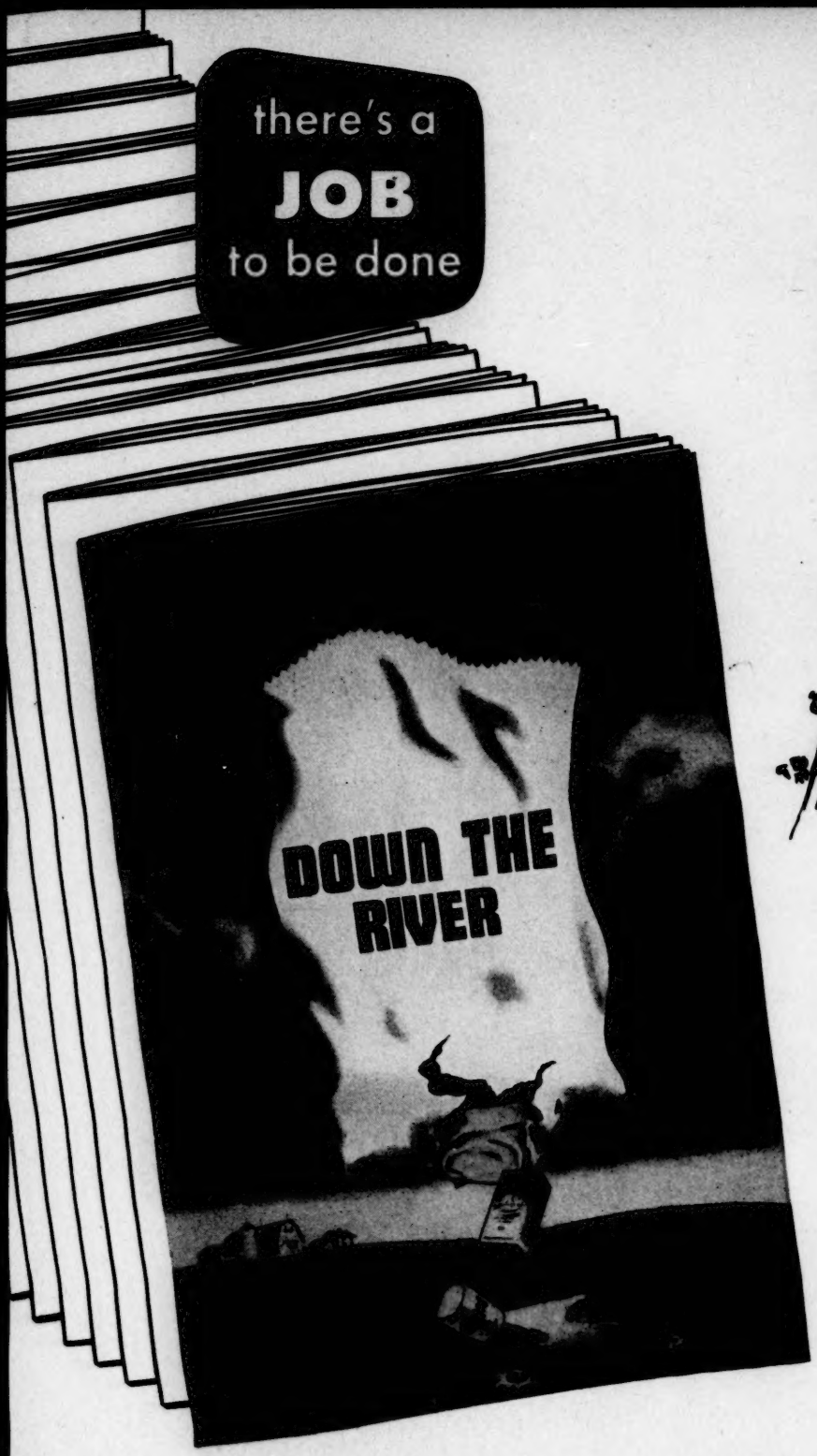

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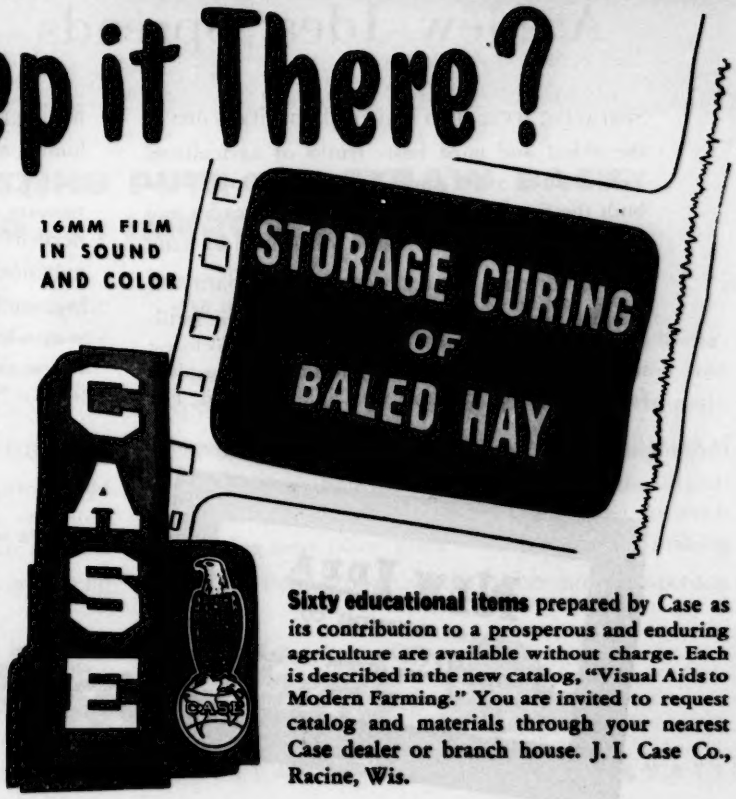

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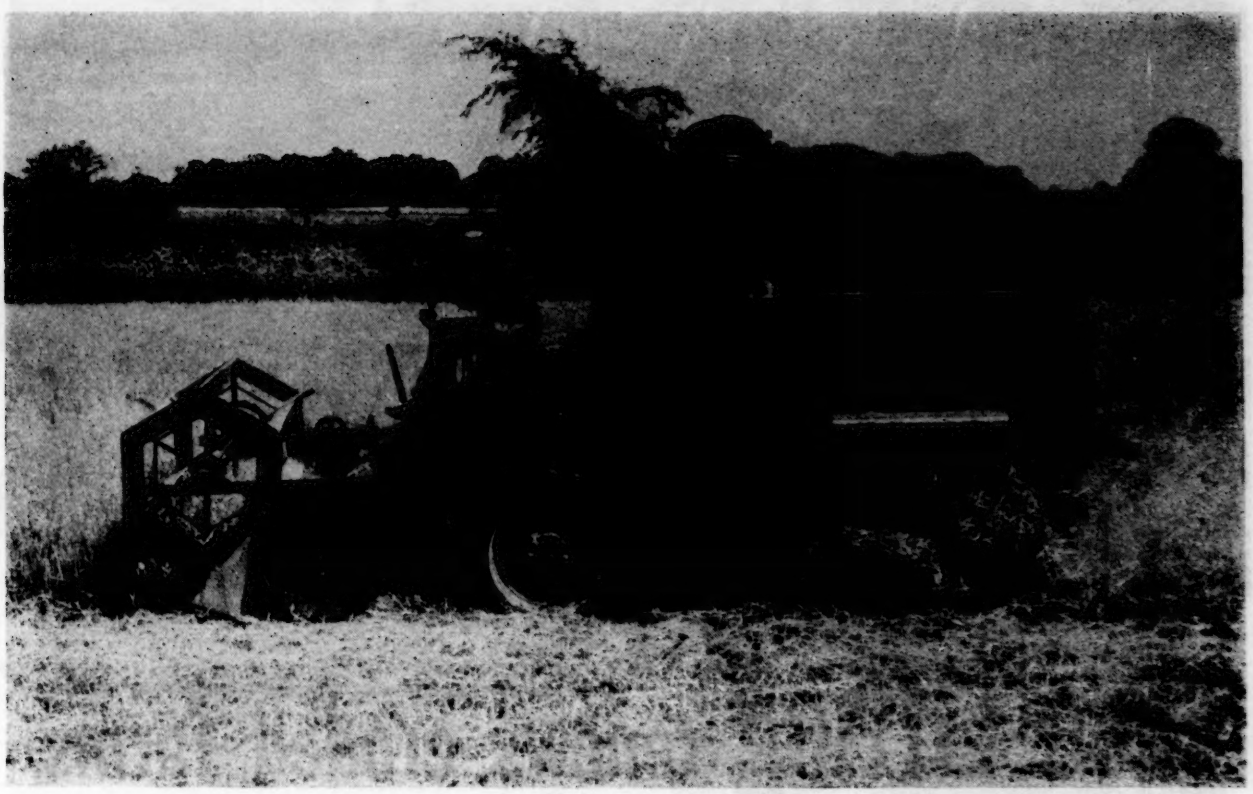

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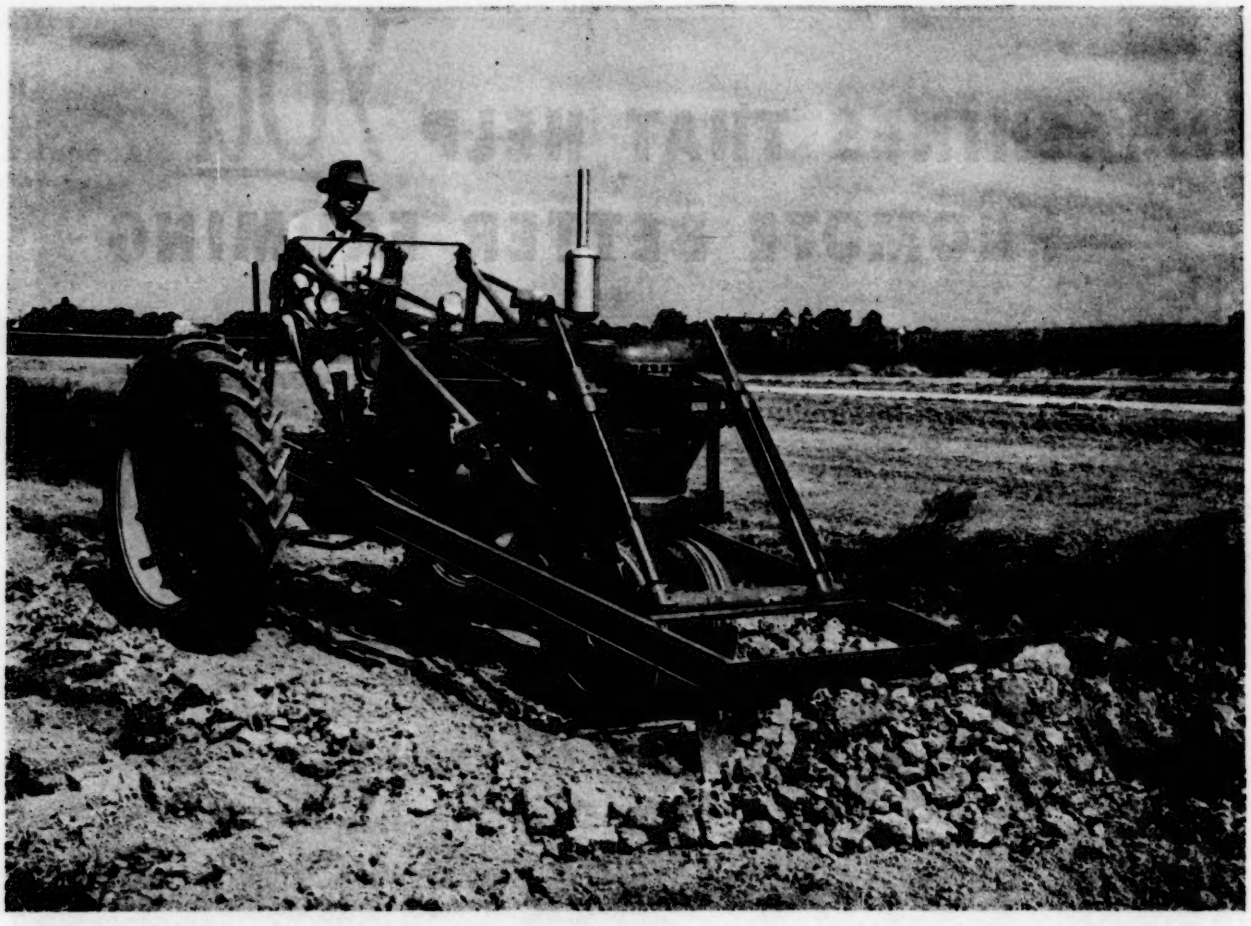

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These sheep, near Bowling Green, Kentucky, are growing fat on the mixture of Ladino Clover, lespedeza and Kentucky '31' fescue while the land is growing fat in fertility and productivity. Back of this meadow is a whole program of fertilization, seed bed preparation, seeding, grazing management and other measures that all add up to complete conservation for these acres.

Photo by Soil Conservation Service

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Signs and Symbols

Man and nature can work together, for the land is bountiful in the hands of a skillful manager. Protected fields and orchards on the George Follweiller farm, Berks County, Pa. *Photo by S. C. S.*

THIS is the age when soil conservation comes into its own, a time when farmers—individually and collectively—resolve to preserve their own little corners of the good earth.

Soil conservation has its signs and symbols. Often the first-seen sign is one of warning—a small gully gnawing into sub-soil; or light spots on the knolls, tell-tale marks of sheet erosion; or falling yields, the signal of tired and worn-down soil.

Farmers are quick now to heed the signs of wasting land. Shrewd traders, they swap the danger signs for symbols of soil conservation—the contoured row to slow the bouncing raindrop, terraces to make running water walk, farm ponds to hold the run-off for awhile, 'til garden, pump, or cow can put it to a use.

Those are obvious and visible symbols, but there are others — thick sods of grasses and legumes; lime and fertilizers, working quietly in the soil; green manure and manure spreaders; trees to cover the ragged and rugged lands, while growing countless useful crops and, along with berry bushes, harboring the birds and animals which choose the freedoms of living wild. Another symbol is the crop rotation, invisible except to experienced eyes, yet perhaps the most valuable soil-management practice yet devised for plowlands.

The future of successful farming rests upon soil-conserving, soil-building methods, whose symbols—seen and unseen—compose the trademark of continuing prosperity for American agriculture.

JOHN DEERE

MOLINE ILLINOIS

A New Concept—Using Chemicals For Soil Structure Improvement

C. L. W. SWANSON

It is too early, points out Dr. Swanson in this informative article, to evaluate the usefulness of Krilium in crop production. Additional research needs to be done under various soil and crop conditions before dependable recommendations can be made.

Generally speaking, the use of Krilium in soils high in clay improves the structure, increases their porosity and permeability making them easier to work. It also reduces cracking and crusting of the soil surface. Under certain conditions, Krilium can be used to control soil erosion.

MORE THAN A CENTURY AGO, Liebig came up with the idea that chemicals could aid in the growing of plants. He used sulphuric acid to treat bones so that the phosphorus in the bones was made in a form available to plants. From that original idea and small beginning, today we have millions of dollars invested in factories which produce chemical materials used as fertilizers. These chemical fertilizers supplement the natural fertility of our soils. They are said to be responsible for about 20 per cent of the increased crop yields obtained in the last few years.

Why Chemicals for Soil Structure Improvement?

If chemicals are such a boon to increasing crop yields and we supposedly are in a chemical age, why can't we use chemicals as a substitute for natural materials for the improvement of soil structure? Clays and organic matter bind soil particles together. Can a chemical be found to do this?

Perhaps the Monsanto Chemical Company did reason just like this. It may have been the impetus which spurred them on into this field of research which culminated in the finding of an organic chemical now used as a synthetic soil conditioner. This new chemical is given the trade name of Krilium. It may well rank as an important a discovery as chemical fertilizers.

The knowledge and know-how of how to improve and maintain soil tilth for maximum crop yields has been obtained through research. Apparently, the stumbling block in the application of these research findings has been the difficulty encountered in getting enough organic matter added to the soil, either as legumes and grasses, manure, or as manure substitutes. Since we are short of organic matter and probably will not find practical ample supplies in the foreseeable future, perhaps the new chemical Krilium can serve a useful role as a synthetic soil conditioner. If it does this, it will be repeating the part played by fertilizers in crop production. Without the use of chemicals, crop yields would be far below what they are today.

C. L. W. Swanson, a Member of the Soil Conservation Society of America, is Chief Soil Scientist for The Connecticut Agricultural Experiment Station, New Haven, Connecticut. Mr. Swanson is a frequent contributor to the JOURNAL.

Past Research Provided Clues for Soil Structure Improvement

Soil scientists long have known that poor soil structure means poor crop yields. They have known, too, that organic matter improves structure and increases yields. Their basic research shows what happens to soils when structure is improved—the soil particles are bound together into stable aggregates, the air space is increased and water and air can get in and carbon dioxide produced by plant roots can get out. They know that the organic matter of our soils is being depleted and the soils becoming hard, compact and in poor tilth because of a lack of it. They know that this deterioration of soil structure means less infiltration of water and since the water cannot flow into the soil it has to flow on the soil surface down the slope carrying soil with it, producing erosion.

Researches by the Soils Department of this Station may serve as one example of the deterioration of soil tilth. These researches show that when Connecticut's cultivated soils are compared with those in forest, the cultivated soils have lost more than half of their original organic matter and one-third of their nitrogen. They weigh two and a half times more than the forested ones and the cultivated soils in poorest tilth weigh 40 per cent more than the most productive cultivated soils.

The turning under of grasses and legumes and applying manure to the land have long been used as a source of organic matter. But under the intensive cultivation now prevalent with modern machinery, the organic matter in soils has decreased tremendously, and we have not generally added enough organic matter to replace that lost. Searches for manure substitutes have been made. At this Station, peat bolstered with fertilizers have increased sweet corn yields as much as 25 per cent over fertilizers alone on a Merrimac sandy loam and at the same time, increased the organic matter content 35 per cent. Wood chips, to which one pound of nitrogen to every 100 pounds of dry chips had been added for decom-

position, increased the water-holding capacity of Cheshire loam one-fourth.

Research was not limited only on how to improve soil structure but also included investigations on the nature and action of the chemicals contained in organic matter which improved structure. Undecomposed organic matter *per se* has little aggregating affect on soils. It exerts this aggregating effect after it has decomposed into "humus." Chemically humus is composed of natural gelatinous water-soluble gums consisting principally of polysaccharides or polyuronide resins. The role of these natural gums in binding soil particles together has been elucidated by Shorey and Martin (13), Martin and Waksman (4), Martin (5, 6, 7) Quastel (11) and others.

Several soil scientists (1, 7, 9, 10) have attempted to improve structure by adding naturally-occurring polyuronic acid salts and other chemically-related polysaccharides to soils.[1] They were not successful principally because the large amounts required (five to ten tons per acre) were uneconomical and impractical. These natural soil binding gums also were rapidly decomposed by soil bacteria making frequent replenishments necessary. Furthermore, it takes time to decompose organic materials into humus-type chemicals. Decomposition released large amounts of cations (sodium, potassium or ammonium) which caused harmful effects, and the large amounts of carbon introduced caused denitrification if extra nitrogen was not added for decomposing it.

What was needed was a chemical that would improve soil structure quickly and not produce deleterious effects such as was obtained when large quantities of natural organic materials were added to soils. In having this basic information, a search of chemicals possessing these favorable properties was needed. This actually is what happened in the Central Research Department of the Monsanto Chemical Company in Dayton, Ohio. Chemists conducted an Edisonian-type search for this chemical, screening over 700 samples before Krilium was found (2).

What is Krilium?

Chemically, Krilium is a synthetic polyelectrolyte resin consisting of a sodium salt of a hydrolyzed polyacrylonitrile. It is a long chain, organic molecule, somewhat similar in structure to the nylon molecule. It is water soluble and in aqueous solution exists as a polyanion with 100 or more negative charges on the individual molecule. The average molecular weight is not known because of the difficulty of such determinations on multiple-charge ions. It is believed, however, to be in excess of 50,000. It is made from the primary raw material, acrylonitrile, using a two-step process to polymerize and then hydrolyze it to produce the soil conditioner. The same base material is used in making butadiene acrylonitrile rubber. It contains no plant nutrients so does not serve as a fertilizer. Once added to the soil it is immobile and does not leach out. It does not appear to be subject to oxidation or to attack by soil organisms. Indications are that Krilium retains its aggregating power against decomposition in some cases ten times as long as the natural crude organic matter. The Monsanto Chemical Company reports that in structure improving power, one pound of Krilium seems equivalent to the natural gums produced by 100 to 1000 pounds of manures or plant residues. The chemical structure of Krilium as represented by Monsanto is shown in Figure 1.

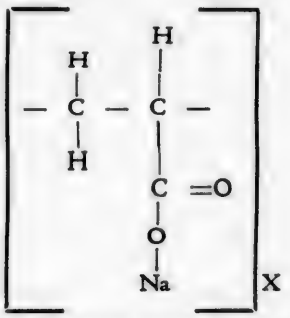

Figure 1. Chemical structure of Krilium

How Krilium Aggregates Soils

Investigations by Ruehrwein and Ward (12) give some clues on the mechanism of soil aggregation by polyanions. From their experiments they concluded that polyanions adsorb on clay by means of anion exchange and that the saturation level of the polyanion (Krilium) is about equal to the anion exchange capacity of the clay. For kaolinitic clays the anion exchange capacity ranges from 3 to 15 miliequivalents per 100 grams of dry clay. This means that the kaolinite-type clay could adsorb only as much polyanion as would be equivalent to their anion exchange capacity. They would then be saturated with the polymer (Krilium). In their experiments, the polyanion was adsorbed to the extent of 2 m.e./100 g.

Polyanions, in themselves, do not flocculate clays. If a polyanion like sodium polyacrylate (Fig. 1) is added to a water-clay suspension, the polyanion will make the suspension more peptized, i.e. the clay particles will tend to remain small and not coalesce to form aggregates, settling out of the water. Although the polyanion will be taken up slowly to some extent by the soil clay through the anion exchange mechanism, the highly negatively charged polyanion will keep the polyanion-clay particles from joining together to form aggregates.

Their experiments showed, however, that if an ex-

[1]The work of Van Bavel (13) in using methylchlorosilanes for waterproofing soil aggregates as one means of increasing their stability should be mentioned.

traneous electrolyte like sodium chloride was present in the water-clay suspension, the polyanion molecules could be adsorbed more easily on the clay. Evidently the sodium ions furnished by the sodium chloride reduced the strong repulsive forces set up between the highly negatively charged polyanion molecules. With reduced repulsive forces, two polyanion molecules could be adsorbed more closely on the clay surface. This allows for a more close packing of the polyanion on the clay surface and, hence, more adsorption of the polyanion.

On the basis of the above investigations, Ruehrwein and Ward (12) believe that carbon linkage "bridges" consisting of polyanions (*Krilium*) form between clay particles holding the clay particles together. It is possible for sodium polymethacrylate to bridge between two clay particles since the molecules are several thousand Angstrom units long, comparable to the dimensions of a clay particle. By means of anion exchange, the polyanions are strongly adsorbed on the clay to form anchor points for the bridge.

Apparently the polyanion molecule ionizes in a water solution and the Na ion dissociates from the parent molecule, leaving a free negative electrical charge. The diagram in Figure 1 presumably is a basic unit repeated more than 100 times (as represented by the negative charges) to form a long chain complex organic molecule. By means of anion exchanges, these free negative charges combine with positive charges on a clay particle. Presumably the attraction of the negative charge of the polyanion for the positive charge on the clay particle is stronger that that exerted by most naturally occurring anions in soils.

Evidently what Krilium does is to assist soils in flocculating to form aggregates (Figure 2) and once they are formed, prevent the aggregates from breaking up again. It appears to take more force to pull a polyanion (Krilium) off a clay particle once it has been adsorbed by anion exchange than it does to pull apart two clay particles which have joined without the use of Krilium. In this way, the bonding or bridging action of the polyanion acts as an aggregate stabilizer, preventing dispersing of the aggregate again to individual clay particles. Since most natural soils contain sodium, calcium, magnesium and other cations, electrolytes are present for affecting the stabilizing action of Krilium.

Diagrammatically, the action of Krilium (12) may be shown as follows:

Experimentally	Soil Clay Particles	Soil Condition
Clay suspension	0 0 0 0 0 0	Poorly aggregated
Na^+ added	0 0 0 0 0 0	Weak aggregates formed, easily dispersed.
Polyanion (*Krilium*) added	⌒ ⌒ ⌒ 0 0 0 0 0 0 ⌒ ⌒ ⌒	Aggregates stabilized by bridges. Aggregates strong.

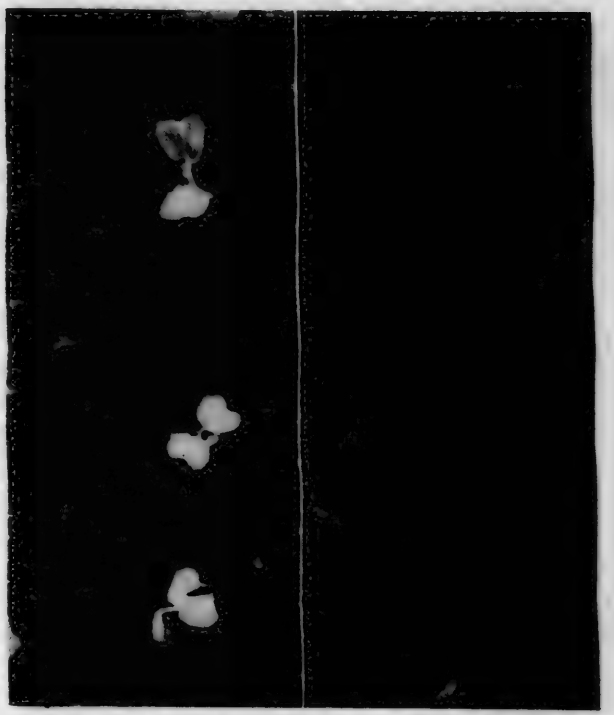

Figure 2. Radishes planted in soil treated with Krilium, left, and in untreated soil, right, show contrasts in growth. Watering dispersed the unstable aggregates in the untreated soil, producing soil cracking and a surface crust. In the Krilium-treated soil, the aggregates persisted making conditions more favorable for germination and growth of radishes.

Soil and Crop Responses from Applications of Krilium

At the Ohio Agricultural Experiment Station, the new soil conditioner has been investigated since 1950.[2] It has been tested by Martin et al (8) under a variety of soil conditions using different application rates and methods of in corporation in conjunction with crops believed to be responsive to structural improvement.

From 0.02 per cent to 0.20 per cent of Krilium was added in powder form to field soils and worked in by disking or rototilling. The soil conditioner, without exception, increased soil aggregation, porosity, permeability, etc. Large crumbs (aggregates >2 mm.) have been mostly produced with total aggregation often exceeding 80 per cent (Tables 1, 2, 3, 4). Moreover, the aggregates proved to be water stable and the conditioning chemicals highly resistant to decomposition. Structural improvement persisted through the second growing season (Table 3).

Some of the crops tested in statistically controlled field experiments were the following: Field (Table 2) and sweet corn (Table 4), oats, soybeans, sugar beets,

[2]Information courtesy of W. P. Martin.

red beets (Table 4), turnips, carrots, potatoes and the small seeded legumes, alfalfa and birdsfoot-trefoil. Not all of these crops have responded to soil conditioner treatments although in general yield increases have occurred. For example, field corn grown on Miami silt loam subsoil which had been treated with as little as 300 pounds per acre of soil conditioner incorporated by disking yielded 15 bushels per acre more than untreated soils. Oats planted as a nurse crop for alfalfa on Crosby silt loam yielded 40 per cent more on treated soils. Marketable carrots were increased 21 per cent in treated Brookston silty clay loam; potatoes and sugar beets in the same soil did not show significant increases but dug easier and came out of the ground clean. Corn and red beets showed marked growth responses to treatment of Paulding clay with Krilium and matured more quickly (Table 4). No toxicities have been noted at any time.

Table 1. Aggregation of Different Soils Field Treated With CRD-186. Ohio Agricultural Experiment Station. 1950-51.

Soil and Treatment	Percent Clay (<0.002mm)	Percent Aggregation >2mm	2-0.25mm	<0.25mm
Miami Silt Loam				
Untreated	20	6	24	30
0.05% 186		24	26	50
Brookston Silty Clay Loam				
Untreated	26	8	29	37
0.05% 186		33	25	58
Paulding Clay				
Untreated	57	11	34	45
0.05% 186		63	22	85

Table 2. Aggregation, Bulk Density and Saturation Water Permeability of Paulding Clay Treated With CRD-186. Paulding County, Ohio, Field Experiments, Ohio Agricultural Experiment Station. 1951.

Treatment	Per Cent Aggregation (>0.25mm)	Bulk Density (Gm./cm³)	Permeability (In./Hr.)
Untreated	56.8	1.35	2.2
0.10% 186	89.9	1.21	26.6

Average of 12 replications. Sweet clover sod incorporated autumn 1950; corn grown in 1951; yields were 19 per cent higher in treated soils. Treated May 21, 1951.

Table 3. Duration of Aggregation Produced in Miami Silt Loam by Treatment With Different Soil Conditioners. Agronomy Farm, Ohio State University. 1950-51.

Treatment	Per Cent Aggregation (>0.25mm) July '50	Aug. '50	April '51	Nov. '51[1]
Untreated	31	31	30	28
0.05% 186	49	53	51	41
0.05% 189	....	49	44	34
0.05% 190	....	32	39	30
0.50% 186	75	79	90	60
0.50% 187	86	84	89	54
0.05% 126	75	84	68	65

Treated May 1950. All results are the average of several replications.
[1]Because of plowing, treated soil was diluted with untreated soil.

Table 4. Aggregation and Crop Yields—Paulding Clay Treated With CRD-186. Paulding County Experiment Fields, Ohio Agricultural Experiment Station. 1951.

Treatment	Per Cent Aggregation (>0.25 mm)	Sweet Corn[1] Height (In.)	Sweet Corn[1] Increase Over Untreated	Red Beets[2] Wt./30 Ft. Row (Lbs.)	Red Beets[2] Increase Over Untreated
Untreated	45	12.1	.....	6.7	.....
0.05% 186	85	21.3	76%	7.7	15%
0.15% 186	94	24.4	102%	8.7	30%

[1]Growth periods: 8/2/51 to 9/18/51; 29-45 plants per plot measured.
[2]Growth period: 8/9/51 to 10/12/51; Some beets in 186-treated soils ready for table use (>1" diameter), none in untreated soils.
Randimized block experiment with six replications. Treated May 18, 1951.

Tests on alkali soils were conducted during 1951 by L. E. Allison of the U. S. Salinity Laboratory at Riverside, California.[3] He found that Krilium gave significant increases in aggregation in soils containing high amounts of exchangeable sodium. The permeability of these high sodium soils also was significantly increased. Use of the synthetic conditioner increased production of sweet corn on these saline soils through improvement in soil aggregation, permeability and reduction in surface crusting.

The Use of Krilium in Erosion Control

A major use of Krilium may be expected to develop in treating banks and slopes to protect them temporarily against erosion until vegetation develops (Figure 3). In combating erosion, the soil conditioner mechanically "holds" the soil in place. This helps to improve drainage, minimize packing and slaking and aids seedling germination and emergence.

Two types of treatment are possible. The first, a surface treatment to control erosion, requires little treating effort and aims at stabilizing the surface of the soil with a continuous water-permeable film until a vegetative cover can be sprouted. The second, the conditioner is worked a couple of inches into the soil. This treatment uses more conditioner and is aimed at quickly establishing a good vegetative cover on more level areas. In this treatment, erosion control is effected by aggregating the soil. Water will then enter the soil more easily and less water will run off thereby decreasing erosion.

About one pound of Krilium per 100 square feet seems to control soil washing. This is about equivalent to straw

[3]Information courtesy R. Q. Parks.

Figure 3. Vegetation was established on the left side of slope where soil was treated with Krilium in contrast with erosion on untreated soil at the right. Test plots established by the Civil Engineering Department of Ohio State University.

mulching at a rate of two to four tons per acre. The synthetic conditioner has advantages in not being unsightly like mulches, carries no weed seeds and in dry weather does not present a fire hazard.

Testing of Krilium for erosion control on highway banks was done during 1951 by J. L. Wright,[4] Roadside Development Engineer of the Connecticut State Highway Department at three locations in the State. He combined the seeding, fertilizing and Krilium applications all in one by spraying the material on the bank.

Observations show that Krilium controlled erosion fairly well, and aided to some extent in grass growth. It was not equal, however, to hay mulch in controlling erosion, germinating grass seed or growing turf. On the other hand, it is difficult to anchor mulch on steep slopes during high wind storms. Krilium shows considerable promise for this purpose. Also considerably less mulch may be used when Krilium is applied which may reduce the total cost.

Investigations on the effect of Krilium in reducing erosion on agricultural soils were conducted by H. L. Borst of the Ohio Agricultural Experiment Station.[2] The data in Table 5 show strikingly that under the conditions of this experiment, Krilium treated soils lost measurably less soil than untreated soil.

Possible Limitations of Krilium

Little work has been done on soils high in sand and low in silt and clay. Reliable predictions as to the effectiveness of Krilium in these kind of soils cannot be made now. Since the stabilizing effect of Krilium is tied up with clay, it may be expected that with low amouts of clay, the effectiveness of Krilium will be proportionately less.

[4]Information courtesy J. L. Wright.

Table 5. Runoff and Soil Erosion From Krilium-Treated Wooster Silt Loam. Ohio Agricultural Experiment Station. 1951.

Rainfall	*Untreated Soils*		*Krilium-Treated*	
(In.)	Runoff (In.)	Soil Loss (Lbs./ac.)	Runoff (In.)	Soil Loss (Lbs./ac.)
9.68	5.7	3430	0.72	31
	58%		0.74%	

Plot size: 7 x 40 ft.; slope 10 per cent; treated July 3, 1951; last reading Oct. 15, 1951. Eleven rains caused runoff from untreated soils; five from Krilium-treated. Tensiometer showed high soil moisture in treated soils throughout season.

In a preliminary investigation to check the aggregating effect of Krilium in sandy soils, the author used a Penwood loamy sand which contained, according to the Bouyoucos method, 81 per cent sand, 15 per cent silt and 4 per cent clay. Duplicate tests were run on samples to which CRD 186 was added at 0.02 and 0.10 per cent weight basis rates. Twenty cc. of the treated and untreated loamy sand was placed in 250 cc. beakers and 150 cc. of water added, stirred 20 times, and allowed to settle for 6½ hours. A qualitative test for turbidity was made, based on the visibility of a yellow lead pencil through the walls of the glass beaker and the water-loamy sand suspension. The turbidity observed was as follows:

Sample	Visual Turbidity
Check	Pencil not visible
0.02% CRD 186	Pencil can be seen very faintly
0.10% CRD 186	Form and yellow color of pencil easily observed.

The samples were allowed to come to dryness at room temperature. Five days later, the surface of the check samples had the appearance of fine dust settling on top of a table. The surface of the 0.10 per cent sample appeared rough and in an aggregated porous condition. The 0.02 per cent sample showed this same condition but less markedly. These data suggest that Krilium may be used effectively for controlling wind erosion such as occurs sometimes on loamy sand textured soils in the Connecticut Valley.

In another preliminary experiment, the author and his associates added CRD 186 to non-sterilized greenhouse soils used in potting geraniums in a commercial greenhouse.[5] The composition of the greenhouse soil prepared by the grower was four parts fine sandy loam, one part manure, one part peat and one part coarse sand. Lime and fertilizer was added to meet the nutrient requirements of geraniums and then 0.10 per cent CRD 186 added by weight. Geraniums were transplanted from sand rooting beds to the Krilium-treated and check soils into 2½ inch pots on January 15.

Evidently, in some way Krilium exerted deleterious effects on the geraniums. Stem rot developed in the Krilium-treated soil. The roots were short and few in number or none present at all. The leaves were wilted, drooping and yellow in color (Figure 4). In the untreated soil, the plants generally were growing vigorously and were well rooted. No signs of plant nutrient deficiencies were apparent.

On February 5 counts made on the condition of the Krilium-treated soils showed the following:

Condition of plant	No.	Per Cent
Dead	17	8.1
No roots showing	103	49.3
Few roots showing	65	31.1
Fairly good root development	24	11.5
Total	209	100.0

Since that date, 21 more plants have died making a total of 38 or 18.2 per cent of the total. The plants in the untreated soil, in contrast, all have good root systems.

It is difficult to explain why Krilium-treated soils produced stem rot. Plant pathologists say that to specifically point to any one factor causing stem and root rot is practically impossible. Perhaps the Krilium produced soils which were too well aerated, increasing the nitrification, causing an unbalance in the plant nutrients taken up by the plants. With high nitrogen uptake, potassium uptake may have decreased. Since potassium favors the building of strong plant tissue, if it was deficient conditions for stem and root rot organisms would be favorable. Soil quick tests (3) on January 28, however, showed no nutrient deficiencies. The experiment is being repeated in an attempt to learn the reason why Krilium, directly or indirectly, produced deleterious effects.

[5]G. Ginter and Sons Company, New Haven, Conn.

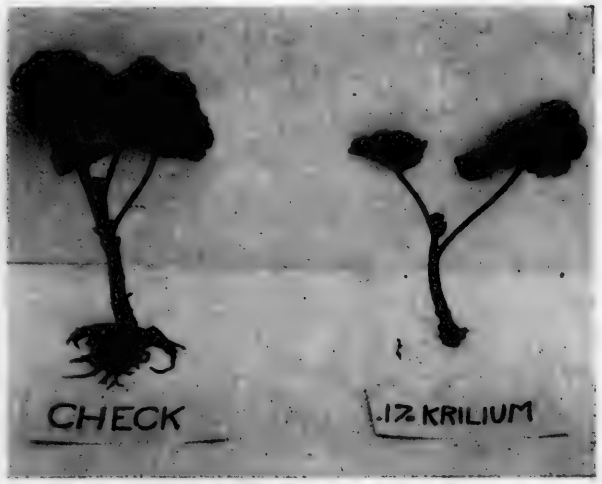

Figure 4. Geraniums grown in untreated and treated soil. The soil was washed off the roots showing striking differences in root growth between treatments.

Observations also show that once Krilium-treated soil becomes thoroughly dried out, it is difficult to wet the soil again, the water running off the surface. Under field conditions, this condition probably will not occur since soils usually have some moisture in them at all times. This drying condition, however, is met with in greenhouses.

The Place of Krilium in Crop Growing

It is much too early to evaluate the usefulness of Krilium in crop production. Additional research needs to be done on the use of this soil conditioner under various soil and crop conditions before dependable recommendations can be made.

Apparently, its use in soils high in clay improves the structure of these soils, increasing their porosity and permeability making them easier to work, and reduces cracking and crusting of the soil surface. Its use improves the structure of alkali soils. Under certain conditions, it can be used for erosion control. The Monsanto Company suggests that one of its greatest potential uses is in commercial greenhouses and in intensive cropping like vegetable production. It may serve as a research tool for studying soil structure deterioration since it decomposes only very slowly while organic matter breaks down quickly.

The fact that Krilium has been found to produce deleterious effects, such as in potting geraniums, strongly suggests that more research on this chemical is advisable. Research will reduce financial losses due to using Krilium under unadapted conditions to a minimum. It may be considered fortunate for agriculture that Krilium is available only for research uses in 1952.

This new chemical cannot be thought of as replacing organic matter entirely for organic matter has several beneficial effects on the soil. It does, however, have the property of sticking soil particles together into crumbs or aggregates and can change a hard, cloddy and crusted soil into one more suitable for crop growing. For years, good soil management practice has been to add organic material to soil to get this mellowing effect. It may replace, in part, organic matter's role in sticking particles together.

Krilium is not a substitute for organic matter as a food source for soil microorganisms nor does it serve as a plant nutrient. Without organic matter, the soil is lifeless and nutrients are not made available to plants. It is conceivable that Krilium may increase the efficiency of organic matter in making conditions more favorable for soil organisms. In doing this, organic matter will be used up faster and additional supplies will need to be added.

Like soils high in fertility which require no fertilization for maximum crop yields, soils in good tilth will require no Krilium for soil structure improvement. Just as it is a waste of fertilizer to fertilize high yielding soils, so will it be a waste of Krilium to apply it to soils which are well aggregated and in good tilth. Under many farming conditions, it still will be the best practice to rely on legumes, grasses and manure for soil structure improvement.

Since Krilium is new, its range of usefulness and limitations is not known. Krilium will be available during 1952 only to scientists interested in conducting research on soil structure improvement. In 1953, the Monsanto Chemical Company expects to have it available for commercial use at about $2.00 a pound. Since 200 to 400 pounds will be required to treat an acre of land about three inches deep, its use at present is economically prohibited only for special crops.

Indications are that this new chemical soil structure fixer has long lasting qualities so its cost can be charged against several years' crops. As with all new products, the introductory price is high but as use increases and volume of production goes up, costs will come down.

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A Natural Resources Policy

Conservation history was made at Miami, Florida Tuesday afternoon, March 18, 1952. At that time A Policy For Renewable Natural Resources was made public after more than two years painstaking development and revision by representatives of the foremost conservation organizations and scientific societies of the Nation. Although each of the organizations and societies that had contributed to the formulaion of the policy statement had for years supported its own particular interests and objectives in the broad field of conservation, the Miami declaration comprises the first occasion for general agreement on a set of basic principles or objectives. Twenty-one groups endorsed the policy in principle, setting the stage for action along a united front for conservation in the months and years ahead.

THE OCCASION for the presentation of the policy was the Seventeenth North American Wildlife Conference, Municipal Auditorium, Miami. After a brief introduction by Ira N. Gabrielson, President of the Wildlife Management Institute which annually sponsors the Wildlife Conferences, Honorable James H. Duff, United States Senator from Pennsylvania, took over as Chairman of the session, with Honorable Clark W. Thompson, United States House of Representatives from Texas, acting as Vice-Chairman. The first speaker, William Voigt, Jr., Chairman of the Natural Resources Council of America, presented the policy statement in behalf of the Council, which is composed of member organizations and societies from various conservation fields. He was

followed by others who spoke in support of the policy statement. They were Honorable Clifford R. Hope, United States House of Representatives from Kansas, who stressed need for watershed planning; Newton B. Drury, who emphasized recreational and aesthetic values; Loyd E. Partain, who discussed exploitation; and Robert C. Cook, who spoke on the human factor in resource use.

The members of the Soil Conservation Society of America can rightly take pride in their part in the development of this policy statement. Original consideration of such a declaration was instigated at the invitation of Dr. Firman E. Bear, then President of the Society, who early in 1950 invited representatives of a few conservation groups to sit together in New York City and determine what might be done. At a second meeting a few months later some progress was made, and at that time it was decided that the Natural Resources Council of America, to which all the organizations in attendance belonged, was the reasonable body to carry the idea forward. In subsequent meetings the Council was able to get a much larger group of conservation organizations and scientific societies to bring to bear their particular interests and concern. Out of several sessions involving exhaustive and detailed phrasing and re-phrasing, the present statement emerged. Admittedly unsatisfactory in some details, and accepted by some groups only in broad principle and with reservation, the existing declaration stands as the first challenge for adequate consideration of an integrated, scientific program for the conservation, development, and use of the Nation's soil, water, and dependent living resources.

The preamble and ten basic points of the policy, together with a list of the organizations that have endorsed the policy in principle, are given below. A separate folder presenting the policy plus a two-page justification, will be mailed later to each member of the Society. Officers and Council members will want member reaction to help in guiding implementation of the policy. It is expected that the present declaration may serve as the basis for obtaining broad action in the conservation field, and that individual organizations might achieve their separate objectives within the frames of reference established by the policy statement.

Preamble

We, the members of the Natural Resources Council of America, in order to provide the means for a high standard of living in a healthful environment, present the following fundamental policy for the use of our basic resources of soil, water, plants, and animals, so as to maintain them through the years and prevent their waste and depletion.

To attain these objectives, we recommend the following policy:

Inventories of Renewable Resources

Adequate and continuing inventories of the renewable natural resources of the nation are needed to determine their condition, productivity, and potential use in relation to human needs and should be supported as a guide to the proper utilization and treatment of these resources.

Scientific Conservation Plan

The orderly development and application of a comprehensive scientific conservation plan for every farm, ranch, small watershed, and other operating unit of the nation's land and water are imperative, and can best be achieved through the efforts of locally controlled groups.

Natural resource developments, including flood control, irrigation, and dam construction, are practically and ecologically most adequate when undertaken in relation to, or in conjunction with, upstream watershed programs.

Policy of Use

A sound policy includes the conservation, development, and proper utilization of renewable natural resources for: (a) sustained and improved agricultural production without waste, (b) protection and sustained-yield management of forest lands, (c) prevention of erosion, protection of streams from excessive siltation, and flood control to safeguard land from destructive overflow, (d) protection of community and industrial water supplies, (e) maintenance of underground water sources, (f) development and stabilization of irrigation and drainage as needed for sound land use, (g) maintenance of maximum fish and wildlife resources, (h) preservation, and proper utilization, of areas best suited for needed recreational, esthetic, cultural, and ecological purposes, and (i) protection and revegetation, where necessary, of grasslands suited to range utilization.

Responsibility of Land Ownership

Good management, public interest, and human welfare require that all landowners, public or private, care for soil and water under their control in a manner that will ensure that future generations may derive from them full enjoyment and benefit. Landowners have no moral right to abuse their lands.

Preservation of Special Areas

A sufficient number of examples of every type of natural area should be preserved and kept perpetually as inviolate natural and wilderness areas for their scientific,

educational, and esthetic values. These should include examples of vegetation types and areas providing habitat for rare plants and animals. Public lands dedicated to special recreational and conservation purposes—parks, monuments, wilderness and primitive areas, wildlife refuges, and similar lands—should not be used for any purpose alien to the primary purposes of the area.

Efficient Resource Administration

All public service should be conducted efficiently to avoid unnecessary burden on the tax-paying public. Any overlapping functions of the several governmental agencies concerned with the administration of natural resources should be eliminated and all operations should be coordinated.

Public Participation in Conservation

Local, county, and state responsibility in regional and basin-wide programs, involving the use and development of soil, water, and the living resources, must include full participation in the planning, financing, management, and other phases of such programs.

National Need vs. Political Expediency

Power developments, flood control projects, irrigation and drainage activities and similar developments, planned and constructed largely at Federal expense, which materially change or influence existing natural resources and their protection or use, should be required to result in national benefit. Justification, economic and social, of projects should be realistic, should be considerate of all values, and should not rest on hopeful expectancy. Methods should be developed for equitable distribution of the project cost among the beneficiaries.

Board of Review

An independent Board of Review, composed of five members who have no affiliation with any federal agency but have outstanding interest in public affairs, should be created to review the need, cost, and desirability of all federal land and water projects and basin-wide programs. This Board should have authority to determine whether or not all projects conform to basic policies. In this way it will be possible to secure planning and consideration at every level of all phases of resources use and management, including not only hydroelectric power, flood and sediment control, navigation, irrigation, and drainage, but soil conservation, forestry, water supply, pollution abatement, recreation, fish and wildlife, parks, wilderness, and all other aspects of the entire program required for the long-range use and care of these resources.

An end product of conservation farming for Illinois farmer Wilbur Francis are these fat steers. Starting on a farm badly eroded and with low fertility, Francis's use of strip cropping, grass waterways, fertilizers, soil building rotations, good land use and other practices have helped him double yields and net income.

Members of this Board should be appointed by the President to serve staggered terms and should be confirmed by the Senate. The Board should have an adequate budget and sufficient personnel to permit the prompt investigation and impartial evaluation of all development proposals. Congress should in its policy statement declare that it will not approve any proposed federal development programs nor appropriate money for such works until the findings and recommendations of this Board of Review are available.

Policy Legislation

To make this policy effective, Congress should pass legislation enacting it into basic law.

The following member organizations have endorsed the Policy in principle:

American Forestry Association
American Nature Association
American Society of Range Management
Conservation Foundation
Ecological Society of America
Federation of Western Outdoor Clubs
Grassland Research Foundation
Izaak Walton League of America
National Association of Soil Conservation Districts
National Audubon Society
National Parks Association
National Wildlife Federation
Nature Conservancy
North American Wildlife Foundation
New York Zoological Society
Society of American Foresters
Soil Conservation Society of America
Sport Fishing Institute
Wilderness Society
Wildlife Management Institute
Wildlife Society

Raindrops Puddle Surface Soil

J. H. STALLINGS

The sharp impact of falling raindrops, as they beat on the naked earth during violent storms, shatters the clods and soil crumbs and breaks down the soil structure. The beating, churning action of these drops compact the soil's finely broken parts into an impervious layer of surface mud to form puddle erosion. Puddle erosion decreases infiltration, increases runoff and soil loss and paves the way for gully formation.

FALLING RAINDROPS have great capacity to erode, damage and destroy soils. The sharp impact, as the drops beat on the naked earth during violent storms, shatters the clods and soil crumbs and breaks down the soil structure into a puddled condition (Figure 1). The beating and churning action of these drops compacts the soil's finely broken parts into an impervious layer of surface mud to form puddle erosion.

This compacted surface layer is made denser and more impervious as it collects colloids and other particles from the turbid rain water that filters down from the surface. Eventually the porosity of this surface layer is practically destroyed by the infiltration of muddy surface materials. Then the important entrance channels to deep soils are closed. The soil-profile material can no longer breathe air freely, nor can it receive and store abundant supplies of rainfall.

A single storm leaves visible effects of puddle erosion only on the surface of a soil. These show as crusts on plowed fields (Figure 2). The surface is glazed like the icing on a cake. Over a long period of years, however, the inflow of turbid water, particularly through cracks and other large openings, may cause the sealing effects to extend deep into the soil profile.

Puddle erosion may be demonstrated by playing a heavy spray from a garden hose on bare ground. Puddling can actually be seen taking place on the surface. Where the ground surface is protected by low-growing plants or by a cover of mulch, it is shielded against the impact of falling raindrops and puddling is prevented. Under these conditions the soil retains its natural structure, and any water that accumulates on the surface remains clear.

Where the raindrops move slowly down through crop or mulch covers to contact the soil without impact, their movements are largely under the control of gravitational forces—passing down stems and leaves of plants. Upon contacting the soil, they come under the influence of strong capillary forces which tend to pull them into the profile, just as ink is pulled into a blotter. This action can be observed when water is placed on the surface of a porous brick. Since high-velocity raindrops can not puddle a brick, the clear water is pulled into the open pores by capillary action. These important and well-regulated workings of nature are violently upset by baring a soil to the challenge of storms.

Puddling Is Caused by Raindrop Splash

It was recognized as early as 1877 that beating rains broke down the soil, washed fine particles into small crevices and pores, sealed the soil surface, and decreased the porosity of the soil (14). It was also observed at the same time that vegetation protected the soil from the damaging impact of raindrops.

The application of artificial rain to cultivated bare soil in Nebraska (9) and to burned-over and bare soils in California (12) resulted in the production of a thin, dense, compact layer at the ground surface. The dispersing action of falling raindrops and the filtering of the small particles suspended in the muddy surface wa-

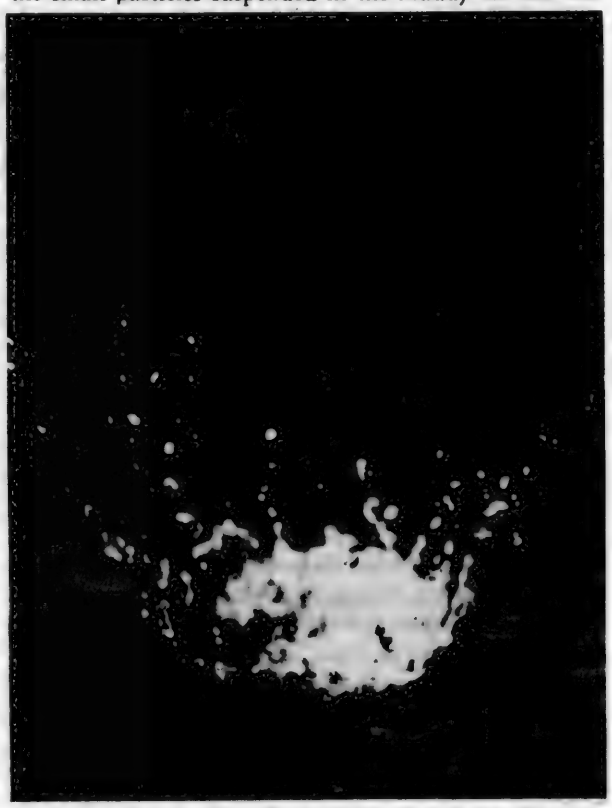

Figure 1. Falling raindrops blast the surface of the soil, shatter the clods and crumbs of soil and destroy its structure.

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ter were thought to be the factors responsible for the formation of this layer. In each case the rate of intake of water at the surface was reduced drastically.

Similar results were obtained when artificial rain was applied to a soil in Texas which was unprotected by a littered forest floor, grass, or other dense vegetal cover. The water immediately became muddied by fine material thrown forcibly into suspension by the raindrops (10). This fine suspended soil material clogged the pores of the soil and increased runoff appreciably.

It was also recognized that at least part of the energy expended in the erosion process resulting from rain was supplied by impacts of falling raindrops (11). Using rain applicators to apply sprays to trays of soil, it was found that as the drop size increased from one to five mm. in diameter the infiltration rate decreased as much as 70 per cent, and the erosion losses—measured in terms of the concentration of soil in the runoff water —increased up to 1,200 per cent. As the size or velocity of raindrops increased, the concentration of soil in the runoff water increased and the infiltration rate decreased. This showed a direct relation between the energy expended by the falling raindrops and the resulting soil losses. It also showed that as the rate of erosion increased, the infiltration rate decreased.

It was concluded that this was a dynamic process, since the magnitude of the concentration of soil in the runoff water varied with the time at which comparisons were made. This indicated that the erodibility of the soil surface changed during the runs.

Vegetal Cover Prevents Puddling

On land covered by vegetation many of the raindrops are intercepted by plants and yield up most of their kinetic energy before reaching the surface of the ground or the surface of flowing water (Figure 3). It was suggested that this diversion of rainfall energy may be responsible in a very large measure for the remarkable reduction of erosion by close-growing crops (5).

The water intake rate of soil that was protected by a mulch of straw showed a much more gradual drop and was maintained at a high level for a considerable time, and even then it did not drop as low as on bare soil (9). This appeared to be due to the fact that the mulch greatly retarded the formation of a compact layer at the surface.

Grass on land in permanent sod had an effect very similar to that of straw mulch in allowing a high rate of water intake for a considerable time after the beginning of the application. Where grass and debris were removed from the surface, the rate of intake fell much more rapidly. The final rate of intake for both a grassed plot and for a clipped plot with the clippings removed was lower than for the straw-covered plot (9).

A study was made of the effects of natural plant cover on infiltration and runoff of rain water on a previously cultivated but abandoned Gilpin gravelly loam. The plant covers represented the more permanent stages of upland plant succession which were typical of the area studied as well as of most of the valleys and lower mountain slopes of central Pennsylvania (1). The purpose was to determine the effect upon rainfall infiltration of various stages of ecologic development on abandoned farm-land areas as shown by vegetation and soil structure differences. It was concluded that this highly erodible soil, when given ample surface protection against the dispersing action of raindrop impacts, was capable of maintaining an adequate infiltration capacity.

Infiltration tests made on native meadow and range pasture land in Arizona and Nebraska indicated that the various grasses tested were effective in preventing sealing of the soil and in inducing a high intake rate of water into the soil (3), (7). However, total cover, including living grass and its associated litter, was more significant than the kind of grass or type of soil.

Tests made in a dune-sand area showed that the grass present had a marked effect on infiltration. The intake on sandhill soil without either the grass or the grass roots on the surface was very much less than where grass was present. It was concluded that the intake rate of water by the soil depended largely on the protection of the soil surface by some type of cover.

Protecting the surface of the soil with wheat-straw mulch greatly increased the rate of water intake on six soil types in Nebraska (8) and orchard soils in West Virginia (13) over that of bare ground. The infiltration rates were high also and remained at relatively high levels throughout long periods of rain application in Nebraska. On the other hand, on all bare cultivated soils where puddling occurred, the total intake of water by the soil was relatively low and the infiltration rates dropped rapidly to much lower points. Practically no soil was lost from the mulched plots.

Straw mulch raised the level of total absorption and rate of infiltration on all soil types. The soils used represented a wide range in texture of surface soils and in the character of the subsoils.

It was concluded that the infiltration rate of the bare soils was due to surface phenomena. That is, the principal factor affecting the intake of water was the condition of the immediate soil surface. The development of an impervious compact layer on the surface reduced the infiltration rate of cultivated soils. This compact layer was formed by rain impact which altered the structure at the surface. This layer was made still more compact by running water which sorted the particles and wedged

Figure 2. The beating and churning action of raindrops striking bare ground puddles the surface of the soil.

and fitted them into close formation. This compaction slowed down the entrance of water into the immediate surface of the soil. Consequently, infiltration was slow and runoff high wherever this condensed layer developed on the surface. This compact layer developed on cultivated land of all the soil types tested and brought their infiltration rates almost to a common level. On the other hand, it did not develop to the same degree as quickly on any of the soils where the surface was protected with a dense growing crop or by crop residues. All soils so protected permitted a high intake of water over an extended period even though they finally showed a greatly reduced infiltration rate.

The total intake of water and the final infiltration rates on cultivated bare land showed much less variation among the different soil types than was anticipated. Despite the fact that the soils tested varied greatly in texture of the surface soil and in profile characteristics, the amount of water taken in during a given time was strikingly similar for all soils and the infiltration rates were finally reduced almost to a common level. Even sandy soils closed up until infiltration was very slow.

Soils covered with a crop had a much higher rate of water intake than bare soils and they maintained this higher infiltration rate throughout the longest tests. The denser crops, like native sod and alfalfa, gave the highest infiltration rates. These high rates were maintained over extended periods. Sod land with grass clipped close and clippings and surface debris removed had a rate only a little higher than bare cultivated soil.

Mulch applied to a soil surface that had been compacted and "sealed" by rains controlled erosion but did not greatly affect runoff in Ohio (4). The mulch softened the raindrop impact, with its destructive effect on the soil surface, but did not reduce the amount of overland flow.

Artificial rain was applied to three plots at the rate of approximately 2.25 inches per hour. The plots were left bare and exposed to the action of natural rain for several weeks. During this period the surface soil became crusted and "sealed." Two of these plots were then covered with straw at the rate of two tons per acre. The straw was placed directly on the surface of the ground on one plot and on the other it was supported on mesh wire an inch above the ground surface. The third plot was left bare. Artificial rain was then applied at the rate mentioned.

It was found that 92.7 per cent of the water applied as rain ran off the bare plot compared with 65.0 per cent for the plot with the surface-applied mulch and 83.2 per cent for the plot with mulch supported an inch above the ground. Corresponding soil losses from these plots were 5.62 tons per acre for bare plots, 0.42 ton for the surface-applied mulch plot, and 0.26 ton for the plot where the mulch was supported an inch above the ground surface.

Further evidence of the dispersing power of raindrop impacts was furnished during this same study. After water was applied to the supported-mulch plot for one hour, the wire and straw were removed quickly while the water continued. The runoff that had been almost clear became muddy and its density increased from 0.19 to 1.15 pounds per cubic foot.

A third variation of this study was developed by using two additional plots on which the surface of the soil was broken to a depth of about one inch and straw was applied at the rate of two tons per acre. Here, as previously, the mulch was placed directly on the surface of the ground on one plot and supported an inch above the surface on chicken wire on the other. Water was applied at the usual rate of 2.25 inches per hour.

The mulch in this instance almost completely eliminated both runoff and erosion. The plot with the mulch resting directly on the surface of the ground lost 1.7 per cent of the water applied as runoff and 0.10 ton of soil per acre. The other plot lost 1.2 per cent of the water applied as runoff and 0.12 ton of soil.

In Pennsylvania, mulching of Hagerstown silt loam with manure, straw, sawdust, corn stover, oak leaves, and pine needles for 3-year and 4-year periods resulted in complete control of surface runoff and developed an infiltration capacity of three or more inches per hour (2). The re-application of these mulching materials on the soil for one day resulted in a very significant increase in infiltration capacity. Although the uncovered plots lost 45 to 60 per cent of the rain applied as runoff, the same plots, when covered with mulch, lost only

three to ten per cent of a 3-inch per hour rain. The chief value of the mulch in controlling runoff lies in its protective effect. Artificial rain was applied in this same series of studies at the rates of 1.5 to three inches per hour in 1941 and 1942. From 75 to 98 per cent of the water applied on the check plots was lost by runoff, whereas no runoff occurred on any of the mulched plots.

In the above experiments, artificial rain was applied at intensities of 1.5 and three inches per hour for at least 60 minutes or as long as necessary to obtain even rate of runoff for approximately 20 minutes before measurements were made.

Puddle Erosion Decreases Infiltration

From experiments on nine widely different soil types in eastern Nebraska, it was concluded that a compacted layer on the surface of cultivated bare soil had a far greater effect on the intake of water than did differences in soil type, degree of slope, previous moisture content of the soil, rate of rainfall, or profile characteristics (6), (7). In fact, it seemed to have a greater effect than all of these factors combined (Figure 4).

Clear water added slowly to a column of screened sand penetrated to a depth of four inches in 21 seconds; to a depth of eight inches in 60 seconds; and to a depth of 13 inches in 109 seconds (10). A similar volume of soil suspension consisting of 60 grams of Bowie silty loam sludge in 500 cc. of clear water was added to a second column of sand. The fine suspended material settled quickly in the form of a thin film about 1/16th inch thick on top of the soil column and remained practically intact. The sludge water took three times as long to reach the 4-inch depth as the clear water. A similar mixture consisting of 60 grams of Kirvin clay sludge in 500 cc. of clear water required eight times as long to reach the 4-inch depth as the clear water. The Bowie silty sludge and Kirvin clay sludge took 3.5 and 7.5 times as long, respectively, to reach the 8-inch depth as the clear water. The Bowie silty sludge took four times as long to reach the 13-inch depth and the clay sludge eight times as long as clear water.

Puddling Increases Erosion Losses

The energy expended by rainfall has a profound influence upon the nature of overland flow (5). It is sometimes assumed that much of the runoff from land slopes occurs as "laminar" or "stream line" flow. It would seem logical to suppose, however, that during periods of intense rainfall, flow that would be laminar in the absence of falling rain is made excessively turbulent by the impact of high-velocity raindrops. This is exceedingly important because laminar flow is practically nonerosive, and it is only when the flowing water becomes turbulent

Figure 3. A large number of the raindrops are intercepted by the plants on land covered by vegetation and yield up most of their kinetic energy before they reach the ground surface.

that it is able to transport substantial quantities of soil.

Destruction of forest litter and consequent exposure of the soil to raindrop action greatly increased the amount of eroded material and reduced the absorption rate of soil in California (12). Suspended particles in runoff water from bare soils were filtered out in the surface soil. This sealed the pores and seepage openings into the soil sufficiently to account for marked differences in the rate of absorption between bare and litter-covered soils.

During the season of 1927-28, chaparral vegetation and its litter reduced both runoff and erosion. Runoff from a similar plot burned clean was 3.7 times greater than the chaparral plot. The erosion was 18.1 times greater.

The ratio of soil loss on litter-covered plots and bare plots was much greater than that for water loss. Consequently, erosion was a more sensitive index to the change of surface condition than was surface runoff. The formation of a fine-textured layer at the surface of a bare soil as a result of filtering suspended particles from percolating muddy water is, therefore, concluded to be the decisive condition which increases surface runoff from bare surfaces. The most important function of forest

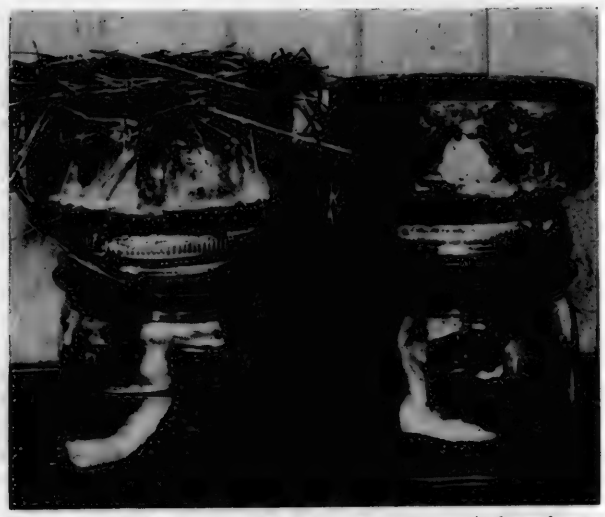

Figure 4. Mulch protected soil from raindrop splash and prevented puddling. Likewise it maintained a high rate of infiltration. Equal amounts of the same kind of soil were placed in splash cups on top of the jars. Mulch cover was placed on the soil in the cup at the left; the other was left bare. Rain was then played on the soil in the two cups for about seven minutes. The greater amount of water in the jar with the mulch cover shows how the mulch cover increased water intake.

litter is to maintain the natural characteristics of a soil profile by keeping rain water clear. With an undisturbed mantle of vegetation the percolation capacity of the soil remains at a maximum even during extremely heavy and prolonged rains.

Puddle Erosion Promotes Gullying

Destruction of vegetation, which exposes the soil to the full force of the processes of surface erosion, also leads to gully erosion which, though different in nature, is often fully as destructive.

Three field plots of Kirvin fine sandy loam, each plot three feet wide and ten feet long, with an 8.75 per cent slope, were used to study the effect of artificially "muddied" water upon the resulting runoff and erosion (10). The water was applied at the upper ends of the plots by means of a sprinkler. One inch of water was used for the first run on all plots. Plot 1 received clear water, Plot 2 received an equal volume of water plus four pounds of Kirvin fine sandy loam topsoil, and Plot 3 received four pounds of screened Kirvin clay. During the first run, both the sandy loam soil and the clay added to the clear water deposited readily and were plainly visible on the upper halves of the plots.

For the second run one-half hour later, approximately the same rate of water application caused water runoff varying from 9.95 to 17.8 per cent, the maximum figure being obtained from the plot receiving water and clay. This time the red clay sheet covered the plot completely, checked infiltration, and induced runoff to such a surprising extent that 1.41 tons per acre of erosion resulted, along with the highest amount of runoff. Neither of the other two plots eroded appreciably.

In another test run, made a month later, the rate of water application was twice the rate used in the previous treatment and the amount of sediment was increased to 16 pounds. Two inches of water were applied in a continuous flow at the upper ends of the plots. Some of the results of this study are given in Table 1.

Table 1.—The effect of increasing quantities of suspended soil materials upon runoff and erosion losses when applied with artificial rain to a natural slope of Kirvin fine sandy loam

Application		Runoff	Soil loss per acre
Material	Two inches in		
	Minutes	*Per Cent*	*Tons*
Water	10.25	54.9	0.17
Water + fine sandy loam	9.25	55.9	3.55
Water + clay	9.25	53.0	9.44

The plot receiving the clear water lost only 0.17 ton of soil per acre, with no gullying or evidence of sedimentation on the surface of the soil.

The addition of 16 pounds of Kirvin fine sandy loam material, however, caused an erosion loss of 3.55 tons per acre—an amount 21 times greater than the loss from the check plot. It is interesting to note that although 16 pounds of sandy sludge was applied, only 4.96 pounds of total soil loss resulted. Gullies formed on the entire plot from top to bottom, but those on the lower half of the plot were refilled with sandy sediment at the end of the run. The soil removed from this plot contained twice as much silt and clay as the original Kirvin topsoil. Nearly all of the sand applied remained on the plot. The erosion process in this instance removed the finer materials from both the applied mixture and the surface soil and deposited the sand.

The addition of 16 pounds of clay caused a loss of 9.44 tons of soil per acre. This was 55 times greater than that obtained from the check. Only 13.19 pounds of total washoff resulted, however, although 16 pounds of clay had been added. Gullies formed on the whole plot from top to bottom. These did not become filled, but on the contrary, they continued to deepen as erosion progressed. The soil eroded from this plot was 53.2 per

(*Continued on page* 88)

Water and Timber Management

MARVIN D. HOOVER

The water produced by forest land increases in importance as our water needs grow because the bulk of our high water yielding areas are forested. With an understanding of the relative values involved and good management, water and timber production are compatible. Too often, timber harvesting causes erosion which reduces the quality of water although logging can and should be done as to avoid damage to the water crop. There are methods for increasing water yields without risking flash floods or water quality but this is possible only on watersheds with good soil conditions. Much of our forest land has been damaged by past agricultural use, grazing, fire and careless logging. The first watershed need on these areas is improvement of infiltration and water storage capacity. The forester should recognize the need and the opportunity for better watershed management.

WATER IS ONE of the most valuable products of the land. Just how important the water resource is has been well shown by the experiences of New York and many other cities in recent years. Forecasts for the future indicate that we will have an increasing appreciation of water. Industrial water requirements grow constantly. In the period 1939 to 1949 industrial water use increased 36 per cent. Even in humid regions, farmers are turning to irrigation to increase their crop yield, and in our homes we continually step up water uses. Along with increasing use of water, our people are concentrating more and more into urban areas creating greater pressure upon municipal water sources. Concern for water is not felt only in Los Angeles or New York. It is just as real in almost all parts of the United States; even the Carolinas and Virginia have been wishing for more water in recent years.

The forester has always assumed a professional interest in water, and much of the popular support for forestry in this country has been associated with concern for safeguarding water sources. However, as timber values increased and timber forestry began to pay off for cold cash in hand, foresters became less concerned with the so-called intangible values of forestry activities. This was understandable enough, but now it is apparent that water vales are not intangible and that we must take them into account when planning forest practices.

Quality of Water and Need Important

Before we consider what the forester can do about water supplies, we must consider what water users need. In simplest terms, the water must be of a quality suitable for the intended purpose and must be available as needed. By quality is meant the physical, chemical and bacteriological properties. Physical properties include turbidity, temperature and sediment content. Chemical properties are determined by the elements dissolved in the water, while the kind and abundance of living organisms determine the bacteriological properties. It is possible to modify the quality of water by treatment, and most water that we use has been treated. This treatment costs money and becomes more difficult and costly as water quality decreases. In the Southeast, the chemical properties of water are good, and cause little concern. Surface water for human consumption is sterilized by chlorination. Reduction of turbidity is a major treatment needed for Piedmont streams before they can be used. This is accomplished by settling basins, chemical flocculation and filtration. Many towns and cities in and near the mountains have water sources clear enough so that filtering is not necessary, and chlorination and chemical amendment are the only treatment required. Such

Figure 1. Skid roads that cross streams are particularly damaging to water quality.

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From 1940 to 1948, Mr. Hoover was in charge of the Coweeta Experimental Forest carrying out research in the relations between forest cover and streamflow. Since 1948 engaged in working out methods for soil improvement to better tree growing and watershed conditions on abandoned agricultural soils of the Piedmont region.

municipalities are particularly vulnerable to disturbances on the watershed which would increase turbidity. However, increases in turbidity are disturbing even if a filter plant is in operation. Settling times are increased in detention basins, more chemical flocculants are needed, and filters must be cleaned more often. All of this lowers output and raises costs. For a city using seven million gallons per day, a gain in turbidity might up treatment cost 1c per 1000 gallons or $70 per day for an annual increased cost of $25,550 per year. From generations of observation as well as actual measurements, we know that water from an undisturbed or well managed forest watershed is of excellent quality and superior to that from other types of land use.

The amount of water available for use depends upon the total volume of stream flow and the seasonal distribution of flows. Unless reservoir storage is developed, the lower-water flow sets a limit upon use. Good forest land, because of its excellent characteristics for water absorption and storage, tends to reduce peak runoff rates and prolong the runoff period. However, total yields may be diminished because the water stored in the soil is subject to transpiration.

Vegetation Influences Movement of Water

The forester is in effect managing a huge detention reservoir. The amount of water which enters and leaves the soil reservoir is influenced by the way he manages the vegetation. Dense stands will increase interception losses and transpiration use of water, while thin stands will have less interception and transpiration but greater evaporation. It is necessariy to distinguish between evaporation and transpiration because evaporation removes moisture mainly from the surface soil, while transpiration withdraws water uniformly from the entire root zone of plants. Differences in rooting habits of plants are important in determining the water used in transpiration. On the Piedmont of South Carolina, for instance, pine trees take water to a depth of six feet, while broom sedge, with more shallow roots, draws only to a depth of three feet. The more water available to tree roots, the more they will transpire. The fact that has been hard to understand is that forest vegetation creates favorable soil conditions for water storage but at the same time uses and intercepts large quantities of water itself. Because of this, it seems that a watershed manager is faced with problems that have opposing solutions. What is good for flood control appears to be detrimental to water yield.

Actually there is less conflict than is at first apparent. A fundamental objective of watershed management is to prevent overland flow of water. Any kind of practice that reduces the capacity of the soil to take in water will cause trouble without compensating benefits. Flash flood flows and muddy streams do not occur from ground water and seepage flow through the soil mantle. Methods for increasing water yields by reducing density or changing cover types are practical only on watersheds with good soil conditions. Most of our forest land in the Southeast has been subjected to careless logging, grazing, fire and past agricultural use. The first watershed need on these areas is management to improve infiltration and moisture storage within the soil.

Where favorable soil conditions are present, we can manage vegetation to increase water yields. This has been well demonstrated by pilot studies at the Coweeta Experimental Forest in Western North Carolina. On two 40-acre watersheds which had an oak-hickory forest, stream flow was measured for a five-year standardization period. The trees were then cut, but to prevent soil disturbance were left where they fell, the tops lopped, and the branches scattered to form a mulch for soil protection. The first year after cutting, stream flow was increased 65 per cent. (The increased water yield was equivalent to a depth of 17 inches over the surface of the watershed.) Stream flow during the normal low-water period of summer and fall was 100 per cent greater than before treatment. On one watershed, regrowth has been kept to a minimum by annual mowings of vegetation, and the same proportional increased runoff has been maintained. Because all runoff is derived from seepage and ground water, flood peaks have been no larger than before cutting. On the second watershed, natural regrowth was allowed, and stream flow has gradually decreased. However, eight years after the clear cut the water yield is still 20 per cent greater than before treatment. Water yields are greater because, with the reduction in transpiration, summer rainfall was sufficient to raise the soil above field capacity so that free water could pass through the soil, recharging the water tables which feed the streams.

Stream Flow Increased by Removing Trees

Experiments at Coweeta and other parts of the country show that trees and other plants growing along streams and in areas where water tables are high use exorbitant amounts of water because they have access to almost unlimited supplies. It is possible to increase low-water stream flow by removing these trees. At Coweeta, cutting all streambank trees within 15 vertical feet of the stream channel increased summer stream flow 20 per cent, even though the area cut over was only 12 per cent of the watershed. Before the streambank vegetation was cut, water levels had been gradually lowered each sunny summer day by transpiration draft, but during the night they built back again. This diurnal fluc-

tuation was eliminated when trees "with their feet in the water" were removed.

These expirements and others clearly indicate that man has the power to change the amount of stream flow by controlling vegetation. Such drastic treatments may find application on certain municipal watersheds where increased yields are necessary and there are no other sources of supply. For more typical situations we will have to develop methods which are more compatible with other uses of forest land. As we achieve greater understanding of the processes involved, it appears reasonable that we can achieve some improvement to water yields and produce timber too. On some forested watersheds, it is likely that we will strive to keep the minimum cover that will protect the soil in valley bottoms and other places where the water table is within reach of roots but practice timber forestry on the slopes. As in all cases of multiple use, compromises must be made which balance the values involved. It will not be necessary that management for water production will always limit timber production. For example, at Coweeta it has been possible to increase stream flow by elimination of a dense rhododendron and laurel understory, and this assists not only water yield but also tree growth.

Logging Operations Create Soil Disturbances

It has been shown that reduction of tree cover is not detrimental to water supply as long as forest soil conditions are maintained. Unfortunately, in most of our timber harvesting we foresters have not fulfilled this latter condition. Most logging operations create considerable soil disturbance, particularly because of the truck roads and skidding trails. Large quantities of dirt may be dumped directly into streams, unstable cuts and fills are made, and areas of impervious surface are created. A small amount of such disturbance is sufficient to muddy the flow of even a good sized stream. This is well shown by a study at Coweeta where a 200-acre watershed was logged by teams and trucks as commonly used in the Southern Appalachians. A total of 2.3 miles of truck road was bulldozed into the watershed to finish the logging job. Turbidity of the water from the logged area averaged 93 parts per million as compared with four p.p.m. for the stream on an adjacent undisturbed area. During storms, the water turbidity on the logged area reached a maximum of 7000 p.p.m. as compared with 80 p.p.m. for the check area. Repeated measurements of road cross sections showed that in four years the 2.3 miles of road lost 6,850 cubic yards of soil. From these figures, it is easy to see why this one logging job was sufficient to muddy the water from the 4000-acre watershed to which it is only a minor tributary. Flash runoff from the roads has also doubled flood peaks. Although the logged area is still forest covered and will produce another crop of timber, its water quality and sediment production are more typical of hillside cornfields than of forest.

Figure 2. Coweeta logged-area skid road 2 years after last use.

Figure 3. Measuring soil loss from the logging road.

Fortunately, there is little mystery about the principles of erosion control and there are examples of good logging jobs which have caused no trouble. The first step in preventing damage is to realize that muddy water can cause downstream damage and make the water unusable for municipal and industrial consumers unless a filter plant is constructed. Muddy water increases the cost in any case. Much of the transported sediment will eventually be deposited in a reservoir, limiting the value of expensive water storage projects. Muddy water also

Figure 4. Weir that measures stream flow from the logged watershed.

harms aquatic life and is ruinous to trout, as well as to other recreational values.

Road and Trail Locations Must Fit Areas

A number of commonsense improvements will go a long way toward lessening damage to water quality. The logging methods used should be suitable to the terrain. For example, in steep country, cable logging systems frequently expose less soil than does truck and tractor logging with its dense network of roads and trails which funnel together creating even greater concentration of water. Road and trail location should receive more attention to avoid steep grades and unstable areas. The road system should be designed to fit the area and the products to be obtained. Too often a low standard road is punched in to reach a particular stand of timber without much thought to possible later use. Or one operator will build a road to get out the saw timber and will be followed by a pulpwood operator who may find the first road unsuitable and then build more road. This lack of system results in more road construction than is actually required to harvest all products. Experiences of this sort show that the location of all forest products in the area, together with a procurement and management plan, should be known ahead of time so that the road layout can be more efficient as well as less damaging to the water resource. The possibility of amortizing the cost of a better road over a period of time rather than paying for a poor road from a single operation should be considered.

The matter of road drainage can hardly be overemphasized. Because roads are usually unsurfaced, the everpresent wheel ruts nullify the use of crowning or sloping the road for drainage. This means that built-in drainage by grade breaks, turnouts, water bars, or open top culverts is almost invariably necessary to prevent erosive concentration of water, and such features must be maintained in operating condition. Most of the preventable erosion from logging occurs during the life of the operation and it is impossible to make up for lack of maintenance if it has been too long deferred, because, by the time repairs can be made, the eroded soil has already been deposited in the creeks. It is customary to consider slides and washouts as being invariably caused by unexpectedly heavy rainfall, when most frequently they are actually due to poor road location, construction and maintenance, with the rain that caused the damage no heavier than usual. As someone has said, "Somehow cloudbursts get to be a lot more common on areas that we log."

On many logging jobs the complications of contracting, sub-contracting, and sub-sub-contracting divide and obscure responsibility. In such a situation no one feels responsible for the preservation of water values. A complete discussion of these considerations is somewhat beyond the scope of this article. In almost all cases, however, the economic problems resolve themselves into one of possible increased initial capital investment versus much higher maintenance costs. Experience has shown that a properly planned and operated logging job, while it may require higher initial outlay of capital, lowers maintenance cost and increases efficiency and profits in the long run.

Obviously, other common forest practices beside log skidding and hauling can also affect water supplies, although few will cause such immediately spectacular changes as does careless logging in a region of intense rainfall and erosive soils. Silvicultural practices by control of stand density and species composition can influence interception, the amount of water transpired and evaporated, as well as soil properties which control infiltration and moisture movement and storage within the soil. Consideration was given earlier to some effects of changes in stand density and species composition upon water available for stream flow. It is important that we learn more about handling vegetation to increase water yields, but it is even more important that we learn how to manage vegetation to improve infiltration and moisture shortage within the soil. The bulk of our present-day forest land has been subjected to fire, grazing, and careless cutting practices. Much of it is abandoned crop land. As a result of past abuse the soil seldom possesses its original capacity for moisture storage and absorption. Improvement of this condition is the first objective of management for water control.

Recording the Intake of Water Into the Soil

MAURICE B. COX

Infiltration of water into the soil with concentric ring infiltrometers has been studied by scientists since the 19th century. The rate of water entering the soil was obtained by recording both the time and amount of water drawn from a calibrated bottle, but this report shows how these measurements can be made with a rain gage.

The instrument consists of the concentric rings, two-carburetor floats, a ten-gallon oil drum, and the recording rain gage. Accurate rates of infiltration were obtained for periods of time as great as sixty hours. A distinct advantage of this equipment is the use of the rain gage for the recording instrument. No altering of the gage is necessary.

Infiltration of water into the soil has been studied by soil scientists, hydrologists and others. Many methods have been used including lysimeters, rain making equipment, and concentric ring infiltrometers. The first work with an infiltrometer was done in Europe, probably in the Nineteenth Century. The use of concentric ring infiltrometers has been common in this country, though not always of the recording type. The Soil Conservation Service has used them in both research and flood control work, and they have been used, particularly on the West Coast, by both state and federal agencies.

A comparison of concentric rings and tubes, representing flooding type infiltrometers with Types FA and F infiltrometers representing artificial rainfall types was made by Sharp, Holtan, and Musgrave[1] in 1939.

These studies showed the flooding types to be more sensitive to soil profile characteristics, while the rainfall types were more sensitive to the protective effects of vegetal cover. They also showed in the extensively replicated comparisons that flooding types tended to give a higher rate of infiltration than did the rainfall simulator types on the same soils.

The concentric ring infiltrometer consists of two metal rings, each eight inches deep, one eight inches in diameter and the other twenty inches. To use these rings, the smaller was centered within the larger and both driven firmly into the surface soil.

Water was then applied to both rings and maintained at a depth of two inches. The rate of infiltration was determined from the amount of water absorbed by the soil within the small inner ring. Until recently, the rate of water taken into the soil was obtained by recording both the time and the amount of water drawn from a calibrated bottle. During 1949, A. D. Bull, Soil Scientist with the Soil Conservation Service, developed a recording instrument for this purpose.

Rain Gage the Recording Instrument

The equipment designed by Bull was not immediately available and recording infiltrometers were needed for infiltration studies on the Wheatland Conservation Experiment Station at Cherokee, Oklahoma. Therefore the device described in this article was developed for recording the intake of water into the soil.

Rain gages were available and tests were made using them for the recording instrument. The recording infiltrometer developed as a result of these tests is shown in figure 1. It consists of the concentric rings, two carbureter floats, a ten-gallon oil drum, and the recording rain gage. The inner concentric ring was made eight inches in diameter in order to correspond with the calibration of the rain gage. By making it the same size as the top of the gage, the water entering the soil was recorded correctly on the rain gage chart.

How the Equipment Was Used

The rings were set and carefully forced into the soil.

Figure 1. A reconnaissance type rain gage was used for recording the rate of water absorbed by the soil in the inner ring of the concentric-ring infiltrometer. The gage should be closed in order to secure a smooth line on the chart.

[1] Unpublished report, "Infiltrometer Studies in the Concho River Watershed in Texas," by A. L. Sharp, H. N. Holtan, and G. W. Musgrave, 1939.

Maurice B. Cox is Agricultural Engineer with the Soil Conservation Service stationed at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma, since August 1939. His activities include investigations in erosion control and reclamation of eroded land, studies of vegetated water channels, machines for brush control, tillage practices and terrace maintenance and hydrologic measurements effecting soil and water conservation.

Figure 2. The automobile carbureter floats and float chambers are mounted on an angle iron support by threaded rods. They are held securely to the angle iron by taps on both sides of the horizontal portion.

Heavy boards were placed across the top of the rings and a heavy soil tamper was used to drive them firmly into the soil.

Water for the outer ring was supplied by gravity through a rubber hose from the drum. The water for the inner ring was siphoned from the previously filled bucket inside the rain gage. The siphon, made of copper tubing and rubber hose, was adjusted so that the tube extended to within a short distance of the bottom of the bucket when empty.

The water level in the two rings was maintained uniform and constant by carbureter floats (Figure 2). The floats were attached to an angle iron support by threaded rods and adjusted to close at exactly the same level when the support was level. Each float was then marked permanently at the water-line with a hack saw. Threaded rods for holding and adjusting the float support were welded on opposite sides of the outer ring. The only adjustment in the field was to set the floats about two inches above the soil and level the support with a carpenter's level.

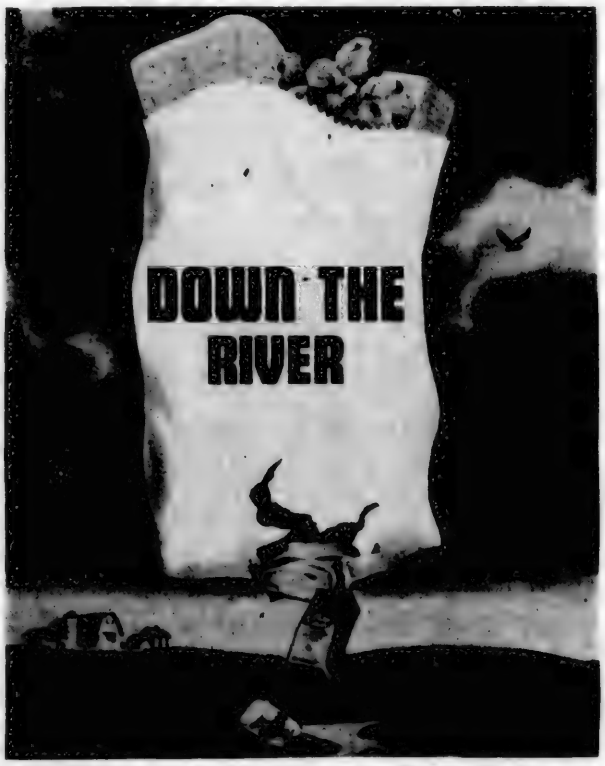
After the infiltrometer was carefully installed and adjusted, the rings were filled to the water-line on the floats from a separate source. The soil surface was protected by a piece of innertube rubber to prevent it from becoming packed or sealed by the impact of the water. As soon as the inner ring was filled, the siphon from the rain gage was primed and attached to the float tube. It is important that the filling of the center ring and the priming of the siphon occupy as little time as possible. If this procedure is not followed, the initial water intake of the surface soil cannot be determined. The supply to the outer ring was attached before the filling was started.

The clocks of the rain gages were equipped with six-hour gears. In some instances, however, four-hour or even twelve-hour gears may be an advantage. When using a gage with a nine-inch capacity and six-hour gears, rates of infiltration as low as 0.02 inches per hour and as high as eight to ten inches per hour can be determined. Gages with six-inch capacity can be read more accurately for the low rates.

A double hook gage was made for checking the setting of the floats in the field. To use this instrument it was pressed down over the edge of the inner ring with hooks in the water and the points barely forming pimples on the surface.

Conclusions

This recording infiltrometer was used on more than 250 locations with excellent results. Accurate rates of infiltration were obtained for periods of time as great as sixty hours. However, the greater portion of the test runs were for 16 to 24 hours. A distinct advantage of this equipment is the use of the rain gage for the recording instrument. The water is siphoned from the bucket, and no altering of the gage is necessary. Gages sometimes available as extra or stand-by units are excellent for this purpose.



The Society's new booklet "Down the River" tells how uncontrolled erosion affects every man, woman and child; also what can be done about it. The SCSA aims to place a copy in every American home.

Airphoto Interpretation Inventory and Planning

HENRY W. DILL, JR.

In studying an entire watershed and planning a remedial land-use program for it, the task of collecting necessary data about the factors that affect runoff presents many problems, especially when the study is made under severe limitations of time and personnel. Mr. Dill describes an airphoto-interpretation method that was used in a study of the Allegheny River watershed to gather information about open land. With this method airphotos were used not only in inventorying the watershed, but also in planning land use; and by using airphotos the amount of field work was reduced greatly.

IN WATERSHED STUDIES (such as the flood-control surveys made by the Department of Agriculture) it is necessary to collect information about the distribution of the vegetative cover—crops, pasture, forest, and the like—on the various soils or soil groups. This information is essential in evaluating soil-cover complexes and their effect on runoff and erosion. It is essential in planning corrective measures that call for changes in land use.

Collecting such information in a usable form has been difficult. There is information about many watersheds, but much of it cannot be used in the form in which it is available. A common difficulty encountered is the matter of the scale on which the data are presented. It is usually either too small (1 inch = 1 mile, for example) or too large (1 inch = 660 feet) for a watershed area. Often a question arises whether data from small areas can be projected to describe larger areas. Some of the available data are incomplete: for many areas information is available about commercial forest land and farm land in production—but not about other kinds of land. Much of the available land-use data is not related to soils at all. Even if land use has been mapped in relation to soils, an expensive planimetering job must be done before the data can be made useful for flood-control studies.

Experience in flood-control surveys since World War II showed that some quick, inexpensive, and relatively accurate method was needed for getting adequate data on the present soil-cover relationships for open and forest land.

Open land presented a special problem, since a flood-control program would include conversion of land from one use to another (crop land to pasture, pasture to forest, etc.). This article is concerned primarily with the procedure used on open land.

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The Method Used

All aspects of the problem indicated that a sampling procedure was needed. Such a sampling method was developed and used during a flood-control study of the Allegheny River watershed.

General information available for the area was studied, such as county soil-survey reports, Census of Agriculture data, etc. This information was then considered in conjunction with the requirements for hydrologic study and program planning. It was determined that data were needed on the distribution of six open-land cover types on ten major soil groups.

Assuming that a sampling method could provide these data, projecting the sample data to describe large areas still presented a problem. Conditions in the watershed varied greatly. (For example, part of the area was glaciated and soils there were different from those in the rest of the area.) A breakdown was needed into areas where conditions were more or less uniform.

Several methods of dividing the watershed were considered: dominant land-use areas, physiographic provinces, soil zones, and so on. Each of these had some merit, but a more general breakdown was needed.

Here two concepts developed by the Soil Conservation Service provided a breakdown that was helpful not only for projecting sample data, but also for recommending future cover on the sample plots used to determine present conditions.

The *soil conservation problem area* concept provided a breakdown into areas of relative uniformity. These problem areas are distinctive units characterized by similar conditions of climate, topography, soil, erosion, and land use. Such areas have been delineated by the Soil Conservation Service in all its regions.

The *Land-use capability* concept provided the means for recommending a sound future land use for any given area. The land-use capability (LUC) class is determined by soil, slope, and erosion conditions. Technical guides[1] have been prepared for determining LUC classes for local conditions in many areas. Further, by deter-

[1] For detailed discussion of these technical guides, see Bruce, O. C., Guides Speed Conservation in Northeast. U. S. Soil Conserv. Serv., Soil Conserv. 13: 137-139. 1948.

Figure 1. A stereo pair of airphotos, showing sample plots located by means of a template.

mining the LUC for all sample plots, the area of the watershed not requiring treatment in a flood-control program could be established. This would provide a more accurate determination of program needs and costs.

Ordinarily, gathering sample data from a large area like this would require an extensive field survey. Time limitations and lack of personnel made this impossible.

However, the use of aerial photographs in forest-survey work by the Northeastern Forest Experiment Station suggested an approach that might be adapted for use in open land. A three-step sampling method was set up, using aerial photographs, to obtain the needed data on open land. Tested in the field, the method provided the necessary data; so it was used in the study of the Allegheny River watershed. In this method the use of airphoto interpretation reduced greatly the field study of sample plots.

Essentially, the method worked as follows: The watershed was divided by soil conservation problem areas. In each problem area the sampling method provided data on land cover, soil group percent of slope, and degree of erosion. For each sample plot a future use was recommended according to land-use capability. The sample-plot data were then projected to represent the total extent of a soil conservation problem area in the watershed.

Airphoto Interpretation

To make use of airphotos it was first necessary to select sample plots uniformly distributed over the area and to locate these plots on the photos. The total number of photo plots desired was determined from a study of the photo-index sheets for the area.

(As an example: If an area is covered by 500 airphotos, and 1,000 plots are to be selected, each photo would have two plots to provide uniform distribution.)

A transparent acetate template was used to locate plots uniformly on the effective area on each photo (i.e., the area of minimum error in the central part of the photo). Holes were drilled into the templates so that plot locations could be marked on the photos.

(In actual practice it was not necessary to mark the plots on the photographs permanently, since records were kept. Some nonpermanent material such as a

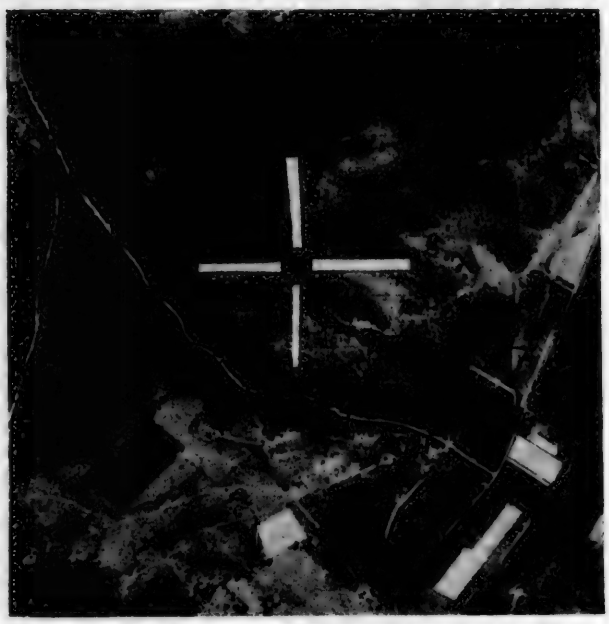

Figure 2. An enlargement showing the uppler sample plot located on the airphotos in Figure 1. On field examination this plot proved to be abandoned pasture with poorly drained soil, 8-15 per cent slope, and 25-75 per cent of topsoil removed.

china-marking pencil can be used for marking photographs temporarily. Thus photographs borrowed from other agencies can be used without defacing.)

The sampling technique involves three major steps: (1) Visual classification of all the photo plots; (2) stereoscopic interpretation of a smaller number of the plots, selected systematically; and (3) field examination of a selected sample of the stereo plots.

Visual Classification

The visual classification consists of studying the plots located on the photos with the template (using a hand lens when necessary) and classifying each plot. The following classes were used:

Definitely forest.—Land bearing forest growth or land from which the forest has been removed but which shows evidence of past forest occupancy and is not now in other use. Narrow strips of trees, such as fence rows and stream margins less than 100 feet wide, and small groups of trees less than one acre in area that are surrounded by nonforest land, are considered nonforest. As a general rule, lands that are or were in pasture or cultivation are not considered forest unless 10 per cent of the area appears to be covered by tree canopy.

Definitely agricultural land.—Includes crop land, hay land, and pasture land. It includes three phases of each of the classes: (1) in production, (2) idle, (3) abandoned. It does not include permanent farm roads, farm buildings, wooded fence rows, or small areas of woodland less than 100 feet wide or less than one acre in extent.

Definitely other land.—This class includes urban areas, roads, railroads, rights-of-way, water swamp, streams, areas of bare rock, quarries, sand dunes, and wooded areas less than 100 feet wide or less than one acre in extent. Such areas as cemeteries, golf courses, or park areas that can be recognized as such are included in this class. So are strip-minded areas and oil-well operations, including access roads.

Doubtful land.—Areas that are difficult to put definitely in one of the three other classes are designated as doubtful land. Border-line cases (sometimes the result of a poor aerial photograph) are included in this class.

During the visual classification the smaller number of open-land plots to be studied more closely by stereoscope was selected on a systematic basis, i.e., every third agricultural-land plot, every other definitely forest plot and so on. A tally of all photo plots was kept, by land-use classes. Plots selected for stereo interpretation were marked on the photo and the photo number and land class were recorded so the plots could be studied in detail later.

Stereoscopic Interpretation

Stereo pairs of definitely agricultural plots selected for interpretation were examined in detail by steroscope and four main types of data were obtained: (1) detailed land use, (2) soil group, (3) slope group, and (4) soil-erosion class.

Detailed land use.—In the stereo study, land use on the selected plots was determined in detail as follows:

Row crop
Close growing (small grain)
Hay land
Good pasture
Poor pasture

Idle land and abandoned land were not included in the stereo land-use classes. It was not possible to identify idle or abandoned land as such from the photos. It was believed that the proportion of idle or abandoned land could be derived from crop land, hay land, and pasture in the field examination.

Soil group.—The soil at each of the sample plots was classified in one of the following groups set up for hydrologic evaluation and for a guide to formulation of a remedial program.

(1) Well-drained sandstone and shale
(2) Well-drained glacial till
(3) Well-drained colluvial and terrace
(4) Glacial outwash soils
(5) Imperfectly drained
(6) Poorly drained
(7) Very poorly drained
(8) Shallow soils
(9) Rough stony areas
(10) Bottom soils

Slope group.—Following classification of the soil, an estimate of the slope class was made. The following two sets of slope classes were used for different soil conditions:

For well-drained soils	*For colluvial, imperfectly, and poorly drained soils*
(*Percent*)	(*Percent*)
0 - 5	0 - 2
5 - 12	2 - 8
12 - 25	8 - 15
26 - 40	15 - 25
over 40	over 25

Soil-erosion class.—Amount of soil erosion for each plot was estimated. It was shown by one of the following classes:

(1) Less than 25 per cent erosion.
(2) 25-75 per cent of topsoil removed.
(3) 75 per cent or more of topsoil removed.

(4) All of topsoil and 25 per cent subsoil removed.
(5) Severely gullied land.

For any plot, making the photo-interpretation was a matter of judgment based on experience. Determination of slope is a good example of the interpretation technique. A typical plot under consideration was apparently not level-to-gently-sloping (0.5 per cent slope) and obviously not over 40 per cent slope. Thus two classes were eliminated and the possibilities were reduced to three. Experience from field work and in the use of photos will decrease the error in estimating the correct class.

The photo-interpretation data for each plot were listed by cover classes and by photo number for further use in selecting field check plots and for use in the field examination.

Field Examination

The final step in the method was a field examination of a number of selected plots that had been classified by stereoscopic interpretation. The total number to be studied in the field depends on the time, personnel, funds, available for this work, and the accuracy desired. After the total number of field plots that can be visited has been decided upon, the number to be taken in each of the land-use classes is determined according to the relative ease of interpreting a given class. For example, cultivated land or land being plowed was relatively easy to identify on aerial photos. Poor pasture was more difficult to identify, since it might be classified as good pasture, abandoned pasture, or even hay land. Therefore a larger number of poor pasture plots were checked in the field.

In the field examination the correct cover, soil group, slope, and amount of erosion were recorded on a field form. During this field study, errors in photo interpretation were corrected as well as any errors due to changes since the date of the photography. By the nature of the system, errors in any item could be applied on a percentage basis to the larger number classified by photo interpretation. This error in turn could be applied to the still larger number of photo plots that were examined without stereoscope.

After any errors in soil group, slope group, or erosion were adjusted, the land-use capability was determined for each plot. Technical guides prepared for local conditions were used. A recommendation for future land use was thus provided for each sample plot in addition to the inventory data on present condition.

The field examination provided an additional item: The amount of idle and abandoned land mentioned previously. Field checks indicated that a certain number of the plots for each land-use class were now or had been either idle or abandoned. The number of those plots applied to the total in the particular class thus provided the amount of idle and abandoned land in the major categories of crop land, hay land, and pasture. Additional data provided by field examination included the type of forest planting (hand planting, machine planting, etc.) on areas to be converted to woodland, and the acreage of poor pasture and the type of treatment required to produce good pasture.

Practical Application

At this point the whole method might be clarified by following the technique on one sample plot. It is assumed that by chance the plot was considered in all the steps in the process. The sample plot rated as follows in the various steps:

1. *Visual Classification:*
   Definitely agricultural land.
2. *Stereoscopic Interpretation:*
   Poor pasture.
   Shallow soil.
   12-25 per cent slope class.
   25-75 per cent of topsoil removed.
3. *Field Examination:*
   Abandoned pasture (correction for this applied to total of stereo poor pasture plots).
   Shallow soil.
   26-40 per cent slope class (correction for this error applied.)
   25-75 per cent topsoil removed.
4. *Land-Use Capability:*
   Reference to local technical guide assigns land with such conditions of soil, slope, and erosion to LUC Class VII. Class VII land is generally recommended for conversion to woodland.
5. *Future Land-Use Recommendation:*
   In this case, therefore, the best land use is woodland, and a change from present land use is recommended.

Summary

Four main advantages are apparent in the photo-interpretation method for open-land inventory. First, the required data in a usable form can be obtained with economy of funds and personnel. Second, present land-use inventory and proposed future changes are determined on the same basis. Third, expensive field work is reduced greatly and used where it will do the most good. Fourth, the method provides an estimate of areas not requiring a remedial program; this allows for more careful estimates of extent and costs of remedial measures.

Book Reviews

ADVANCES IN AGRONOMY. *Volume 3. Edited by* A. G. Norman. *Academic Press Inc., New York, 1951. Pp. 361. Price, $7.80.*

This is one of a series of annual volumes prepared under the auspices of the American Society of Agronomy. It contains nine articles that were written by G. W. Burton, H. J. Harper, J. A. McMillan, R. O. Parks, R. F. Reitemeier, R. W. Simonson, A. L. Taylor, C. J. Willard, and E. Winters, respectively. These are reviews of recent findings on alfalfa, soil potassium, British agriculture, grasses for the southeastern states, nematod control, soil conservation, and irrigation. The article by McMillan, who is on the staff of the British Ministry of Agriculture and Fisheries, is of considerable interest in that it deals with the effects of war on the agriculture of England and Wales. The one by Harper is of special importance to the readers of this Journal, since it has to do with the history and development of the conservation movement in the United States. This article, an excellent presentation, merits careful study by all those who are concerned with soil conservation and problems related thereto.

—Firman E. Bear, *New Brunswick, N. J.*

GRASS BEYOND THE MOUNTAINS. *By* Richmond S. Hobson, Jr., *Published by J. B. Lippincott Co., Philadelphia, New York, 256 pages. $3.75.*

This is not a technical book but the true story of modern exploring that led to the discovery of a great new area of grass in British Columbia. The author is the son of a distinguished American Admiral and was scheduled for Annapolis and the Navy. That he did not follow in his father's footsteps is fortunate for those of us who love a rollicking tale of pioneering and adventure. This personal narrative is well worth reading for its character studies of men and horses and for the light touch used in dealing with quiet heroism of these pioneers of the North.

There is something for nearly everyone in this book. The habits of, and adventures with, such animal inhabitants of the Northland as the moose, grizzlies, and giant timber wolves receive considerable attention. The land and climate—muskeg, mountains, meadows, range grass, and arctic blizzards—are treated as they relate to establishing a four million acre ranch. Two unusual cattle drives are described and there is a heart warming story of the night when the horses raced with death.

The author is aware of the conservation problems of our range lands. In trying to figure a way to keep their fabulous discovery free of small ranchers and 160 acre homesteaders Hobson "had ugly visions of other cattle countries I had seen, where, soon after settlement, they became overgrazed pasture lands with soil erosion cutting away the top soil. . ." This problem was finally solved by organizing a cattle company with the necessary resources to keep the new range "in its wild natural state through the years to come—an immense made-to-order cattle land where great herds of Herefords would transform the idle grass into beef, to help feed a world whose production of meat and other foodstuffs was not keeping pace with the relentless growth of its population."

—J. C. Dykes, *College Park, Maryland*

UNION BAY. *By* Harry W. Higman and Earl J. Larrison, *American Book-Knickerbocker Press, Inc., 1951, $4.00.*

For conservationists here is a book that is sure to develop a deep appreciation of the inter-relationship of plant and animal life. It is a simple story of ecology in a marsh area. Not only are the influences of these living things one to the other clearly described, but also carefully portrayed is the influence of man on the marsh area and of the area on man. Each is very profound.

This story of community life, of plants and animals together, of the enemies of each, of the effects of storm and weather changes, of the habits, needs, and characteristics of many birds, animals, plants, and fish that occupy the marsh at one time or another, and of the results of the slightest change in environment is truly a masterpiece of reporting. Wisely, the authors have incorporated in their narrative the knowledge of other investigators on many of the subjects.

For the nature lover it is a friendly narrative packed with the day to day and season to season experiences and observations of the two authors. Written in the first person, as though by one author, it provides an interesting and easy style for the reader. This living, rather complete story of a marsh in the City of Seattle combines the precision and keenness of the careful scientific investigator with a touch of the artist. "Unior Bay" is excellent reading, well illustrated with drawings, and very informative.

—Alvin C. Watson, *Upper Darby, Pa.*

THEY ARE YOUR WOODS! *A Guide to the Care and Improvement of Farm Woodlands of West Virginia. By Ross Mellinger, in collaboration with Harry Lee Baker. The Conservation Commission of West Virginia. 1951. Single copies, 25c.*

At last we have a genuine woodlot farmer's friend—a little but mighty publication that deserves to be up there on the shelf over the kitchen table alongside of the Bible, the almanac and the mail order catalog, in every forest-bound homestead in the U. S. A. Ross Mellinger's wood-farming advice is gauged for the black walnut, yellow poplar, white ash, red and white oak country

of West Virginia, but it would come in handy anywhere. Better than half full of well chosen pictures and diagrams, *"They Are Your Woods"* is loaded with how-to-do-it information, every bit of it practical as an axe-handle.

The booklet seems to be roughly organized into three sections covering management, harvesting and protection. However, Mellinger brings up many items in rapid order and one is never conscious of the usual pigeon-hole documenting of more pretentious tomes. Rather, each turn of the page is a sparkling new experience in farm forestry practice and sound observation.

On weeding treeland, improving sprout woods, thinning, harvest cutting, pruning, laying out woods roads, hauling, and marketing—and all phases discussed—Mellinger talks to his farmers in their language:

"You only have so many stalks of corn on an acre of land and still have good ears. If too many stalks are planted and not thinned, they get spindly and do not ear out well. . . . There is a limit to the amount of wood that can be grown on any one acre of woodland. Either the growth is spread among crowded trees of spindly form or forced to grow on well-spaced crop trees. Thinning out thick young woods will speed up the growth rate of reserved crop trees."

That Mellinger knows well his readers is evidenced by his powerful round-up of dollars-and-cents woods management: *"Fifty cents may look just as big to you ten years from now as a dollar does today, and have the same buying power. You are going to want to buy things then as now. Saving the young, thrifty timber helps insure future income. Except for temporary drops in the market, there is usually a good demand at premium prices for high quality timber."*

Finally, the author asks, "Can You See Other Things in the Woods Besides the Timber?" Thereupon, Conservationist Mellinger deftly points out the watershed, wildlife and recreation values of farm woodland; plus wood hobbies farm folk can turn to profit in wreath- and basket-making, herb and shrub culture.

—BERNHARD A. ROTH, *Upper Darby, Penna.*

BOBBY BLUEGILL. *By R. W. Eschmeyer. Illustrations by Maynard Reece. Fisherman Press, Inc., Oxford, Ohio. 1952. $1.25.*

"Bobby Bluegill," the principal character in this book, is a tiny fellow who first cast his fishy eye on the world from the protected depths of a farm pond—the kind conservation leaders are urging farmers to build for their economic improvement. "Bobby" is the story's moving force, its hero and many times its near-tragic figure.

More than once "Bobby" seemed destined to a short life as big mouth bass eyed him as a choice morsel or as a fisherman dropped a plump worm right in the center of his world. But he escaped, he knew not how, and came in time to fulfill his destiny—sitting on a nest of bluegill eggs and swimming away when they were hatched.

The story's theme is conservation and it is interestingly developed. Jerry Johnson, a typical farmboy, liked to fish, and so did his father, but they had to go far to enjoy this hobby. Then came a conservationist one day to their community. He showed a movie. Jerry and his father were there and the idea of a farm pond was born.

The pond came into being not long afterwards and with the aid and advice of another specialist, with special knowledge of fish and other wildlife, bluegills and bass were stocked. It was inevitable that the little fish would in time outnumber the big ones and fishing would get poorer and poorer. It was then that Jerry and Mr. Johnson learned that nature provides a balance in the animal world. And they also learned another economic lesson—that food supply must be sufficient to support abundant animal life.

The Johnsons went on to develop their little pond. Trees were planted. Ground cover was provided for small game. The pond was fertilized. Muddy runoff water from higher ground was stopped. In time fishing again was enjoyed and the pond was brought to a state of full usefulness to the farmer, his family and his friends.

Meantime, "Bobby Bluegill" was coming of age and enjoying his subsurface existence to the full. As he grew the bass troubled him less and less. Muskrats built a home nearby. There were bugs and microorganisms aplenty for food, and cool, clean water for him and his thousands of finny friends.

"Bobby Bluegill" should be required reading for all early teen-agers and for adults, too, who want to know more about farm ponds and conservation. It is a delightful story.

Billy Bass and *Tommy Trout* are others in a series of story books written by Dr. Eschmeyer. *Billy Bass* tells of fish food and the effects of stream pollution. In *Tommy Trout,* the reader learns that forest fires may destroy fishing as well as hunting. Others to follow are *Sammy Salmon,* who ends in a can; and *Carl Carp,* the foreigner.

—FRED SCHROEDER, *Fairmont, W. Va.*

GEOGRAPHY OF RUSSIA. *By* N. T. MIROV. *John Wiley and Sons, Inc., New York, 1951. Pp. 362, Maps 34. Price $6.50.*

The author of this book, originally a forester, lived and worked in Russia as a young man but is now a citizen of the United States. In writing the book he has endeavored to develop the subject in a somewhat more

elemental manner than that employed by L. S. Berg and other well-known Russian geographers, to whom he is indebted for a large part of his information. The book gives a general picture of the country, describes the people, and then considers 20 regions in detail, with reference to topography, climate, soils and vegetation, animal life, and people. Special attention is given to Northeast Siberia and Kamchatka. The land area is set at 8.6 million square miles. Of this, about four million square miles is occupied by permanently frozen ground. The population is estimated at 210 million, of which the Russians comprise 110 million, the Ukranians 36 million, and the Belorussians 10 million. A relatively small percentage of the people, six per cent, are more than 60 years old. One of the most important features of the book is the large number of maps by which one can visualize the regions referred to. The book is a highly important contribution to the subject, notably in connection with the present emergency.

—BERNHARD A. ROTH, *Upper Darby, Pa.*

New Conservation Bulletins

Terraces on Grassland. *By* MAURICE B. COX, HARLEY M. ELWELL, *Oklahoma Agricultural Experiment Station, Stillwater. Bulletin No. B-733, September, 1951.* A study of terraced and unterraced areas on eroded, shallow soil, before and after revegetation with native grasses. Results obtained show that large, over sized terraces were actually detrimental to grass production and water conservation.

Conservation Problems and Achievements. NORTH CENTRAL REGION PUBLICATION No. 23, *Ohio Agricultural Experiment Station, Wooster, Ohio. July, 1951.* This circular summarizes the long-time conservation experiences on a selected group of farms located in Wisconsin, Illinois, and Ohio. Information presented covers a ten-year period and includes changes in farm organization, investments, operating costs, crop and livestock productivity and finally *net farm income.*

A guide for Soil Conservation District Supervisors. *By* M. D. BUTLER, *Extension Soil Conservation Specialist, State College of Washington, Pullman. Extension Bulletin No. 454, August, 1951.* The duties of soil conservation district supervisors are highlighted.

Land Capability Methods for Conserving Washington Soils. *By* WARREN A. STARR AND L. C. WHETTING. *Popular Bulletin No. 200, 1951. State College of Washington, Pullman.* An excellent presentation of physical conditions and conservation programs by physiographic zones.

How to conduct an Instructional Field Trip Relating to Soil Conservation. *By* EDGAR L. WRIGHT, *United States Indian Service, Washington, D. C.* This very fine publication outlines the various steps that should be considered in conducting a field trip. It is especially directed to teachers and others concerned with conservation education.

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A Report of Sedimentation in Schoharie Reservoir (*New York City*). *By* WILLIAM R. MOORE *and* H. JAMES FERRIS, *Soil Conservation Service, Upper Darby, Pennsylvania.*

This is a report on a detailed sedimentation survey of Schoharie Reservoir, a part of the New York City water supply system. It is thorough in every respect, including specific recommendations.

Conservation Film

PIPELINE TO THE CLOUDS. *Color with sound. Running length 25 minutes. General Electric Company, Schenectady 5, New York.*

"Pipeline to the Clouds" dramatizes the importance of water to the individual and the community.

Speaking at its first showing, Dr. Leonard A. Scheele, Surgeon General, U. S. Public Health Service, underscored today's problems when he stated that "*the demand for water is now four times as great as it was 50 years ago. Since 1900, average per capita consumption has leaped from 50 to nearly 200 gallons a day.*"

The picture not only points up the reasons for many community water supply problems, but also prescribes the means of combating actual or potential shortages. The film was produced with the assistance of the American Water Works Association and the U. S. Public Health Service.

Raindrops Puddle Surface Soil

(*Continued from page 74*)

cent sand, which shows that about 65 per cent of the clay remained on the plot.

SUMMARY

Falling raindrops have great capacity to erode, damage and destroy soils. The sharp impact, as they beat on the naked earth during violent storms, shatters the clods and soil crumbs and breaks down the soil structure. The beating, churning action of these drops compact the soil's finely broken parts into an impervious layer of surface mud to form puddle erosion. This compact surface layer is made denser and impervious as it strains colloids and other particles from the turbid rain water that filters from the surface into the soil. This compacted surface layer is the most important factor affecting the intake of water by the soil. It decreases infiltration, increases runoff and soil loss, and paves the way for gully formation. Puddle erosion can be prevented by keeping the falling raindrops from striking the bare soil. This can be done by employing suitable vegetal covers.

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Terraces are of no benefit when tight-eroded Class VII land is put to grass. Actually they increase water runoff according to a 12-year test at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma. An unterraced field lost only half as much water and made three times as much hay and pasture as an adjoining terraced plot with the same slope and soil type.

An excellent stand of native bluestem grass came in the intervals between terraces, but growth on the ridges was poor, probably due to lack of moisture. Further results of Terraces on Grassland are given in Oklahoma Agricultural Experiment Station Bulletin B-373.

For nine years before the land was put to native grass in 1939, the areas had been in a rotation of cowpeas and cotton. During that period of cultivation terraces reduced runoff 40 per cent. They continued to cut water loss while the grass was being established. However, runoff from the terraced and unterraced grass was about the same by the fourth year and by the fifth season the terraced land was losing the most water. —HARLEY A. DANIEL, *Guthrie, Oklahoma*

land locking

A FLOOD

Top soil valued at a *half billion* dollars began its tragic journey downstream when the Kansas River and its tributaries—and then the Missouri—raged at flood-crest. There went untold future food production from 225,000 Midwest farms . . . by far the flood's costliest toll.

When will nature stage a repeat performance . . and where?

Farmers are getting at the heart of the problem. They are learning to *land lock* floods, back in the fields where floods begin. Allis-Chalmers farm equipment dealers are working with farmers in local Soil Conservation districts, and other groups, demonstrating how regular farm tractors can build and form contours and curving terraces . . . how tractor-drawn subsoilers can penetrate nearly two feet deep in hardened earth where water can be trapped.

Cloudbursts will always swell streams. But runoff can be slowed, and soil held for growing crops instead of clogging reservoirs and dams. Farmers are helping the engineers tame Ol' Man River . . so hunger will stay 'way from our door.

ALLIS-CHALMERS

TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

FIELD NOTES AND COMMENTS

New Jersey Conservation Tour Highlights Land Use Practices

The many tools in the conservationist's kit were shown to 160 interested persons in a 75-mile tour of Sussex County, New Jersey, last June. Sponsored by the New Jersey Chapter of the Soil Conservation Society of America the tour was planned by Wallace A. Mitcheltree, program chairman of the New Jersey section.

Mitcheltree, extension soils specialist at Rutgers University, had the support of 14 state and Federal agencies. Those who took the tour filled in their knowledge of geology, soils, soil conservation, fish, forestry, wildlife, vegetable and grassland farming in one of the state's most picturesque counties.

Timber and grass are the dominant crops in Sussex because of the broken topography, rockiness and steepness of slopes. Timber interspersed with many lakes and high elevation has made Sussex a recreational paradise. The limestone slate portion of the county grows good grass and supports an outstanding dairy industry.

How woodland can be managed for conservation was shown at the farm of Stephen D. Inslee near Springdale. Elwood B. Moore, forester of the New Jersey Department of Conservation and Economic Development, cited the woodlot on this farm as an example of proper harvest cutting to favor a sustained yield over many years.

Extension Forester Austin N. Lentz of Rutgers University explained how abandoned land can be profitably planted to Christmas trees when the group stopped at the farm of Russell Snook near Newton. He showed also how wildlife food shrubs can be planted on steep slopes and a border of multiflora rose can be used effectively next to pasture land.

Also at the demonstration at the Snook farm, Agricultural Agent John Raab spoke of soil surveys and land capabilities. Hudson Roe, Unit Conservationist for the Soil Conservation Service, pointed out 65 acres of contour strip cropping as an example of erosion control for cropland with moderate slopes.

A properly managed pond or lake will produce a greater poundage of fish than a like acreage of land used to feed beef cattle, according to Rolly Smith, biologist of the New Jersey Department of Conservation and Development. He showed species of fish taken from Paulinskill Lake.

At the Dairy Research Farm of Rutgers University the group learned that time of cutting affects the performance and longevity of forage crops. Claude Eby and Dr. M. A. Sprague of the Rutgers staff explained cutting schedules used to maintain desirable species.

A section of the Conservation Tour group inspecting wildlife shrub plantings and a living fence of multiflora rose on the Russell Snook farm.

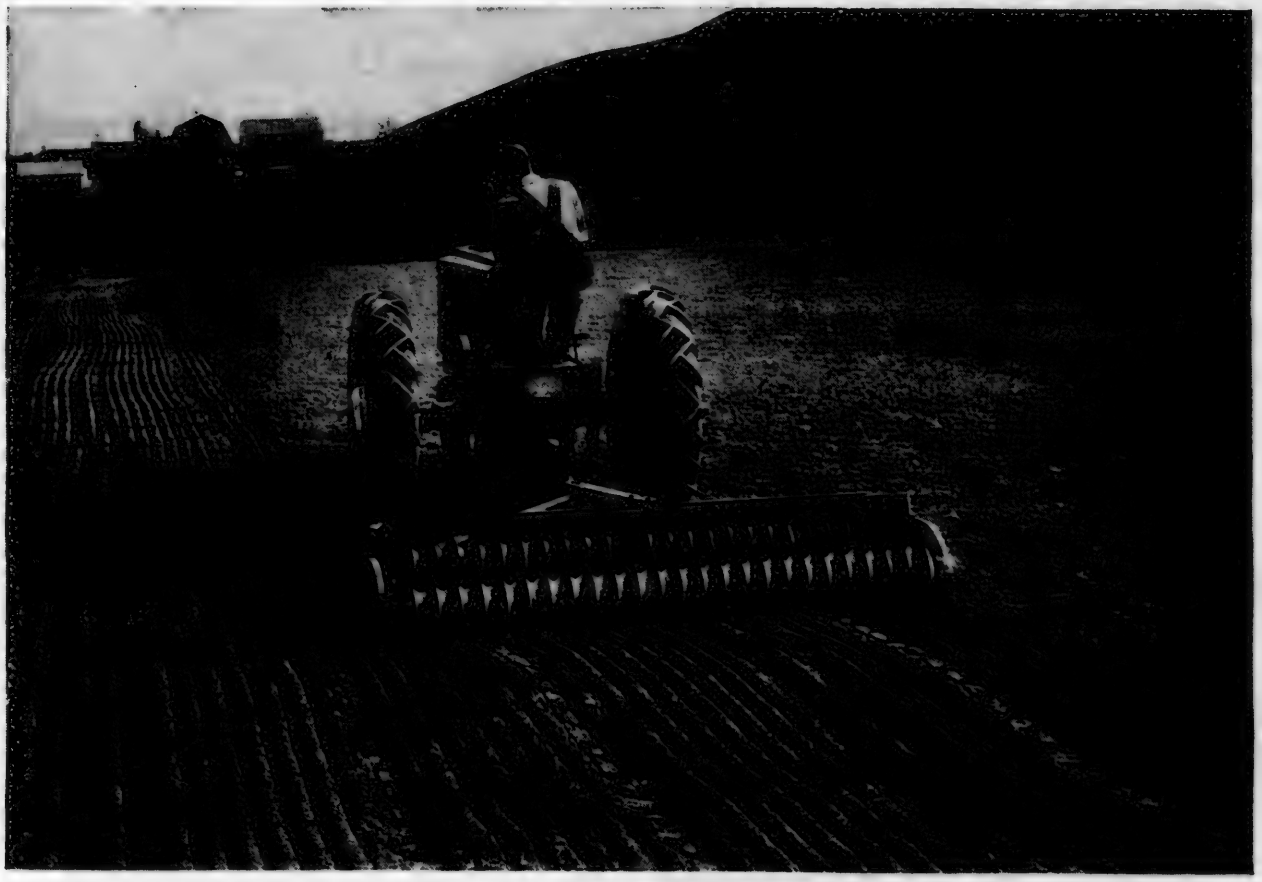
Can an intensive vegetable grower profit by putting acreage to grass? A positive answer to this question was given at the farm of Charles Zabriskie near Ogdensburg. Mr. Zabriskie seeds a grain near the last cultivation or later so that the soil is protected from winter weather.

Soil and water losses are cut to a minimum at the all-grass dairy farm of Jacob Krotje near Lafayette. Mr. Roe explained how Mr. Krotje renovates and makes new sod by growing Sudan grass in summer, followed by rye for fall and early spring pasture. The rye is seeded down to a new grass mixture which results in an all grass or protective grain cover for all his cropland throughout the year.

New Soil and Water Magazine Launched by Texas Districts

Acting with the bold vigor and well ventilated humor that seems always to characterize Texas and Texans, Lone Star soil conservation districts have recently erected what promises to be a bright, new milestone in publications related to doings on American land. Mr. M. C. Puckett, president of the state's Association of Soil Conservation District supervisors, reports 100 per cent cooperation in launching the organization's own monthly magazine, SOIL AND WATER. The 164 districts covering 95 per cent of all Texas soil have contributed generous capital stock to get the production going and carry it through it growing pains.

Response to the magazine's first two issues (January and February, 1952) has been remarkably good, due without question, to a consistent freshness of philosophy and content, that ought to sweep the cobwebs out of



AS GOOD AS A RAIN FROM BELOW

Riding the sky to "seed" rain clouds isn't the most practical way to give newly planted crops a drink between rains.

An older and more dependable way is to put a good mulch on top of the soil, and press out the air pockets below it. Natural laws older than man-made devices begin to operate. They actually pull water up from below to meet thirsty roots or dormant seeds that need extra moisture.

Farmers who use Brillion implements give their soil a "rain from below," for every Brillion implement . . . the Sure-Stand Seeder, Pulvi-Mulcher and Pulverizer . . . leaves a firm mulched seedbed as shown above. It helps speed germination, and improve plant growth and root development — all of which means more money in the pockets of farmers who own and use Brillion implements.

Ask your Brillion dealer how the Sure-Stand Seeder in particular does a moisture-saving job.

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"TUCKS EACH SEED TO BED — IN THE TOP HALF INCH OF SOIL."

THE BRILLION SURE-STAND SEEDER. Seeds legume and brome, pulverizes and packs in one operation. Available in three sizes.

THE BRILLION SURE-STAND GRAIN DRILL. Drills grain, fertilizes, seeds legume and brome, and pulverizes in one operation.

THE BRILLION PULVI-MULCHER. Pulverizes, harrows, mulches and packs. Crushes lumps on top and below the surface.

THE BRILLION PULVERIZER. Available in single, double and triple gang models; and a wide variety of widths.

Brillion — Acknowledged Leader of all the Seeders

many a neglected cranny. Editor John Cole says, . . . "As to the purposes of the magazine, we have no high-flown set of meaningless aims, listed in numerical order with detailed sub-paragraphs. . . . We know this, though: Any man who has tried soil conservation practices on his own land successfully is profoundly interested in the subject; it's no dull subject to him, it's a profit-making venture increasing his income in the here and now, an exhilarating enterprise, and he's interested in every phase of it, the same as a sports fan is interested in the sports page. To keep that man posted on what other landowners are doing with conservation will be one of the aims of SOIL AND WATER, and we hope to do it in such a way he'll be down at his mail box waiting for the magazine once a month. . . ."

A high standard professional appearance, slick, 40-page format and abundant photo-illustrations will help to fulfill editorial hopes. Articles are notably well written and authoritative, and range widely over the big state's variegated agriculture. Sample features, thus far, have included a newsy study of flood control work on the Trinity-San Jacinto and Middle Colorado River watersheds; a popular research piece on rainwater intake records from soils on dozens of local farms and ranches; several success stories, highlighted by a cotton farmer's experience renovating 506 acres that had been devastated by 72 oil wells; a vignette about a top-notch district supervisor; a highly significant piece regarding a conservation-minded ranch manager; an expose relating soil erosion's role in ruination of the Gulf Coast oyster beds; and, throughout, an active awareness of the infinitely potential relationships—banks, schools, industries, newspapers—that can help the land operator get the conservation work done easier and faster.

Of more than passing interest is SOIL AND WATER's audacity in injecting truly relevant humor, including cartoons, into its effort; plus a red-blooded, virile, soil and water conservation adventure story replete with mysterious caverns, defunct horse thieves, ancient Indian relics and cougars ("Along the Butterfield Trail," pp. 32-37, February).

Publication offices are in the Wilson Building, Temple, Texas. Subscription rate is $3.00 per year.

International Grassland Congress Scheduled for State College, Penna.

The Sixth International Grassland Congress under the sponsorship of the United States Government and the Food and Agriculture Organization of United Nations, will be held August 17-23, 1952 at the Pennsylvania State College, State College, Pennsylvania.

In many areas of the world, including the United States, grassland provides a great undeveloped resource which can be used to increase the production of food. Methods for improving and using grassland, in particular the development of new and better varieties of grassland crops, have been the subjects of extensive research in various countries during the past few years. The work carried on independently by those countries has differed in respect to research techniques, production and improvement practices, and the varieties of grassland crops tested.

Representatives of the sponsoring and cooperating agencies, organizations, and societies are members of an Organizing Committee, the chairman of which is Dr. P. V. Cardon, who until his recent retirement was Administrator of the Agricultural Research Administration, United States Department of Agriculture. The vice chairmen of the Committee are: Dr. W. M. Myers, of the United States Department of Agriculture; Dr. S. H. Work, of the North American Regional Office of the FAO; Dr. H. R. Albrecht, of Pennsylvania State College, for the land grant colleges, and Walter Garver, of the United States Chamber of Commerce, representing the various interested trade associations. W. R. Chapline, of the United States Department of Agriculture, is the Executive Secretary of the Organizing Committee.

Approximately 65 countries have been invited by the United States Government to participate in the Congress. The Organizing Committee expects that the Congress will be attended by 2,000 to 2,500 specialists from the United States and other countries. Among those specialists will be agronomists, geneticists and plant breeders, soils and fertilizer specialists, range ecologists, dairy and animal husbandry specialists, economists, and other experts in fields related to grassland production, improvement, management, and utilization.

The program for the Congress, which has been developed by the Organizing Committee, provides for the holding of sectional meetings to discuss various major topics relating to grassland. The topics selected are, as follows: (1) genetics and breeding, (2) improvement and management of pastures, meadows and turf, (3) improvement and management of range lands, (4) ecology and physiology of grasslands, (5) soil management and fertilization, (6) seed production and distribution, (7) soil and water conservation, (8) harvesting and preservation of forage, (9) use of forage in livestock feeding, (10) machinery, (11) experimental procedures in grassland research, and (12) improvement and management of tropical grasslands. Papers on these topics will be presented in either the English, French, or Spanish languages, the three languages which have been selected as official for the Congress.

SOIL AND WATER CONSERVATION GLOSSARY

Prepared by

THE SOIL CONSERVATION SOCIETY OF AMERICA

SECTION II

(*Continued from January issue*)

Forage—Unharvested plant material available for use as food by domestic animals. May be grazed or cut for hay. When cut it becomes feed.

Forage, Native—Indigenous vegetation suitable for food for livestock and game.

Forage Fish—Small, prolific species of fish that serve as prey for predatory fish.

Forage Volume *(Range Management)*—(1) The portion of a plant above ground and within reach of grazing animals. (2) The measure of the forage crop, that is, the aggregate amount of forage produced on a range area during any year.

Forb—Any herbaceous plant which is neither a grass nor a sedge. Ordinarily, forb is used to describe plants which are grazed on western ranges where a term is needed which will include non-legumes as well as legumes but distinguishing them from grasses and sedges. In the east, the term forb is not generally used since any plant on a pasture which is neither a grass nor a legume is considered to be a weed.

Forest—Trees and associated plants covering an extensive area of land. See *Protection Forest; Second-Growth Forest; Virgin Forest; Woodland; Woodlot.*

Forest Influences—The effects of natural vegetation, especially forests, on climate, water, and soil.

Framed Dam—A barrier, generally built of timber framed to form a water face, supported by struts.

Frazil Ice—Granular or spicular ice which forms in agitated water. Riffles and rapids are prolific sources of such ice during protracted freezing temperatures.

Freeboard *(Hydraulics)*—The vertical distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures. Freeboard is provided to prevent overtopping of structures because of wave action or the development of unforeseen conditions.

Free Flow *(Hydraulics)*—A condition of flow through or over a structure not affected by submergence or backwater.

Free Weir—A weir which in use has the tail-water lower than the crest of the weir. Contrast with *Submerged Weir.*

Frequency Curve—A graphical representation of the frequency of occurrence of specific events; for example, a curve showing the number of times a rainfall of given magnitude is likely to occur during a given period of record.

Friction Head *(Hydraulics)*—The head or energy lost as the result of the disturbances set up by the contact between a moving stream of water and its containing conduit. For convenience, friction losses are best distinguished from losses due to bends, expansions, obstructions, impacts, etc., but there is no recognized line of demarcation between them, and all such losses are often included in the term "friction losses."

Friction Slope *(Hydraulics)*—The friction head or loss per unit length of conduit.

Fringe Water—Mobile water suspended in the capillary fringe immediately above the watertable and in the lower belt of the zone of aeration. All interstices are completely filled with water except toward the top of the fringe.

Fungus; pl. ***Fungi***—A low form of plant life having no chlorophyll, reproducing by spores, having a web-like growth called a mycelium, and growing as a parasite or saprophyte on living or dead plants or animals. Fungi are numerous in the soil, where they aid in breaking down organic matter. Examples are yeasts, molds, mildews, rusts, smuts, puffball and mushrooms.

Furrow Dams—Small earth dams used to impound water in furrows. See *Lister.*

Furrow Irrigation—A method of irrigating by small ditches or furrows leading from a header or supply ditch. This may be called *Gradient Irrigation* when the furrows are placed across the general slope.

G

Gage (*Gauge*)—A device to indicate or register a quantity or condition as water level, flow, velocity, rainfall or temperature. In hydraulics, many types of gages are used to measure water levels and velocity of flow; examples, chain or tape, hook, point and staff gage, various types of floating gages and also recording gages.

Gage Height *(Hydraulics)*—The elevation of a water surface above or below a datum corresponding to the zero of the staff or other type of gage by which the height is indicated.

Galled Spots—Small areas that are bare because erosion has removed soil.

Gallery *(Hydraulics)*—(1) a subsurface collector for percolating water; an underground reservoir; (2) a passageway, as in a dam; an underground conduit.

Game *(Wildlife)*—Species of animal life hunted for food, sport, or recreation.

Game Management—The art of making land produce sustained annual crops of wild game.

Game Refuge—A closed area designated for the protection of game animals, birds and fish within which hunting or fishing is either prohibited or strictly controlled.

Geological Erosion—See Normal Erosion.

Girdling—The encircling of the stem of a living tree with a continuous series of cuts deep enough to kill the tree. It is used as a method of killing trees, usually to permit the survival and more rapid growth of more desirable nearby trees.

Glacial Soil Material—Material transported and deposited by glacial action from which soil may be developed.

Glaciation—(1) The covering of large areas of land by glacial ice. (2) The geological action of glaciers, including the wearing down of the earth's surface by moving ice, the transportation of loosened soil and rock material, and the later deposition of this material as till and outwash and, indirectly, the deposition of lacustrine material in glacial lakes.

Governing Body, Soil Conservation District—The appointed or elected supervisors (directors or commissioners) of a soil conservation district. There are usually five persons on this body, two of them appointed by the State Soil Conservation Committee, and three elected by the landowners in the district. The process of appointment or election varies with state laws.

Grade—(1)The slope of a road, channel, or natural ground. (2) The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction like paving or laying a conduit.

Grade Stabilizing Structure—A dam constructed for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head cutting or lowering of the channel grade.

Graded Terrace—A terrace having a constant or variable grade (slope in feet or inches per 100 feet of length) along its length. Contrast with *Level Terrace.*

Gradient—Change of elevation, velocity, pressure, or other characteristics per unit length; slope.

Granular Soil—A soil composed largely of aggregates having rather indistinct faces and edges in contrast with a fragmental soil which is composed largely of aggregates having well defined faces and edges or in contrast with a single grain structure obtained in a puddled soil or in sand.

Grass—A member of the botanical family *Gramineae* characterized by blade-like leaves which are arranged on the culm or stem in two ranks. See *Bunch Grass; Sod Grass.*

Grassed Waterway—A natural or constructed waterway, usually broad and shallow, covered with erosion resistant grasses, used to conduct surface water from cropland.

Gravitational Water ***(Soils)***—Water which exists in the large pores of the soil and which the force of gravity will remove from the soil when conditions for free drainage exist.

Gravity Dam—A dam depending solely on its weight to resist the overturning, sliding, or pivoting forces of the water load behind it.

Grazing—(1) Feed available to animals on ranges and pastures. (2) The process of feeding by livestock on live or standing plants other than browse. See *Continuous Grazing; Deferred Grazing; Overgrazing; Premature Grazing; Rotation Grazing; Undergrazing.*

Grazing Capacity—The maximum number of animals or animal units per acre, or acres per animal unit, which a grazing area is able to support adequately without deterioration. Sometimes called *Carrying Capacity.*

Grazing District—An administrative unit of the Federal range established by the Secretary of the Interior under the provisions of the Taylor Grazing Act of 1934, as amended, or an administrative unit of state, private or other range lands, established under certain state laws.

Grazing Land—Land used regularly for grazing. The term is not necessarily confined to land suitable only for grazing but cropland and pasture used in connection with a system of farm crop rotation are usually not included.

Grazing Period.—See Grazing Season.

Grazing Permit.—A document authorizing the use of public or other lands for grazing purposes under specified conditions, issued to the livestock operator by the agency administering the lands.

Grazing Preference ***(Range)***—In the administration of public grazing lands, the basis upon which permits and licenses are issued for grazing use.

Grazing Season—The portion of the year that livestock graze, or are permitted to graze on a given range or pasture. Sometimes called *Grazing Period.*

Grazing Survey—See Range Survey.

Grazing Unit—Any division of the range used to facilitate range administration or the handling of livestock.

Green Manure Crop—Any crop grown for the purpose of being turned under while green, or soon after maturity, for soil improvement.

Gross Duty of Water ***(Irrigation)***—The irrigation water diverted at the intake of a canal system, usually expressed in depth on the irrigable area under the system; diversion requirement. Contrast with *Net Duty of Water.*

Ground Water—Water standing in or passing through the soil and the underlying strata. It is the gravitational or free water in a zone of saturation. The source of water for wells and springs.

Group Action — A technician or leader working with groups of farmers or ranchers on the planning, application and maintenance of land use, soil and water conservation measures.

Group Enterprise — The application or installation and the maintenance of a conservation measure which serves more than one farm or ranch through the joint effort of those served; examples, construction of a main drainage ditch, realignment of the irrigation system of an irrigation company.

Grove—A smaller group of trees than a forest, and without underwood, planted, or growing naturally as if arranged by art; a wood of small extent. Sometimes used to refer to a *Sugar Grove*.

Growing Stock (*Forestry*)—The total number or the total volume of all the trees. The term may be used in combinations having a more limited meaning; for example, "sawlog growing stock" consists of the sum of all trees large enough to produce sawlogs.

Gully—A channel or miniature valley cut by running water, but through which water commonly flows only during and immediately after heavy rains or during the melting of snow. A Gully may be dendritic or branching or it may be linear, rather long, narrow and of uniform width. The distinction between gully and rill is one of depth. A Gully is sufficiently deep that it would not be obliterated by normal tillage operation whereas a rill is of lesser depth and would be smoothed by ordinary farm tillage. See *Gully Erosion; Rill Erosion*.

Gully Control Plantings — The planting of seeds, seedlings, cuttings or transplants in gullies to establish or reestablish a vegetative cover adequate to control run-off and erosion and incidentally produce useful products.

Gully Erosion — Removal of soil by running water, with formation of channels that cannot be smoothed out completely by normal cultivation.

H

Habitat—The environment in which the life needs of a plant or animal are supplied.

Hardpan — A cemented (indurated) or hardened soil horizon. This horizon which may have any texture is compacted or cemented by iron oxide, silica, organic matter or other substance. Contrast with *Claypan*.

Hard Seed — A physiological condition in which some seeds do not absorb water and germinate when a favorable environment is provided. This may cause delay in germination of some seeds for as long as two years. Hard seeds are frequently found in legumes and tree seeds, and may be important in the success or failure of revegetation.

Harvest Cutting (*Forestry*)—Cutting in any woodland type for the principal purpose of harvesting crop trees of useful value and of any size produced in accordance with the objectives of management or as limited by site, or for salvage of trees damaged or killed by fire, insects, disease or other causes. This cutting is principally trees of rotation age or older, but ordinarily will also include other trees removed as incidental improvement cutting.

Hay—The dried stems and leafy parts of plants such as alfalfa, clovers, other forage legumes, and the finer stemmed, leafy grasses. Contrast with *Fodder; Stover*.

Head (*Hydraulics*)—(1) The height of water above any plane or reference. (2) The energy, either kinetic or potential, possessed by each unit weight of a liquid expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compound terms such as pressure head, velocity head and lost head.

Head Flume—A flume, chute, trough, or lined channel used at the head end of a gully to prevent extension of the gully or at a junction with a terrace outlet to prevent cutting.

Headgate—The control works or the device through which water may be released to enter a conduit.

Headland—A strip of unplowed land at the end of furrows or along a fence.

Headwater—(1) The source of a stream; (2) the water upstream from a structure.

Headworks—The diversion structures at the head of a conduit.

Heaving (*Of Plants*)—The partial lifting of plants out of the ground, frequently breaking their roots, as a result of freezing and thawing of the surface soil during the winter. Death may result from dessication while plants are lifted as well as by injury caused directly by low temperatures. Heaving may cause serious winter losses in alfalfa.

Heavy Soil—See Fine Textured Soil.

Hedgerow—A barrier of bushes, shrubs, or small trees growing close together in a line.

Heel-In—To set plants such as nursery stock in a temporary trench, covering the roots with soil, to keep them from drying out before they are permanently planted.

Herb—A plant in which the stem does not become woody and persistent, but dies annually or after flowering, down to the ground at least; includes both grasses and forbs but is distinguished from shrub or tree.

Herbage—Herbs, collectively, and any other green, leafy food for animals, particularly pasturage.
age.

Herbicide — A chemical substance used for killing plants, especially weeds. Examples include "2-4 D" and other organic herbicides, sodium chlorate, iron and copper sulfates, and calcium cyanamide. Many of the most useful herbicides are "selective," killing some species or groups of plants with little or no injury to others.

Herd—A group of animals, especially cattle or big game, collectively considered as a unit in grazing practices. Often synonymous with band as applied to sheep or goats.

Herding, Close — Handling a band of sheep or goats compactly, and restricting the spread of the animals when grazing.

Herding, Open — Handling a band of sheep or goats whereby the animals are allowed to spread rather freely in grazing, but ordinarily quietly and without trailing.

Highway Erosion Control—The prevention and control of erosion in ditches, at cross drains, and on fills and road banks within a highway right of way. Includes vegetative practices and engineering practices.

Hollow Dam—A barrier usually of reinforced concrete consisting essentially of slabs supported by transverse buttresses. The load is taken by the slabs and transferred to the foundations through the buttresses.

Hulled Seed—Any seed normally covered by a hull, that is, by bracts or other coating, from which the hull has been removed. Syn. *Dehulled Seed.*

Humid—A term applied to regions or climates where moisture, when distributed normally throughout the year, should not be a limiting factor in the production of most crops. The lower limit of precipitation under cool climates may be as little as 20 inches annually. In hot climate it may be as much as 60 inches. Natural vegetation is generally forest. Contrast with *Subhumid.*

Humidity, Absolute—The actual quantity or mass of water vapor present in a given volume of air. Generally expressed in grains per cubic foot or in grams per cubic meter.

Humidity, Relative—The ratio of the actual amount of water vapor present in the portion of the atmosphere under consideration to the quantity which would be there if it were saturated.

Humus—(1) Organic matter that has reached a more or less stable advanced stage of decomposition. It is usually characterized by its dark color, considerable content of nitrogen, a carbon-nitrogen ratio approaching 10:1 and by various physical and chemical properties, such as high base exchange capacity, water absorption and swelling. (2) The plant and animal residues in the soil that have undergone some appreciable degree of decomposition.

Humus Layer—The top portion of the soil which owes its characteristic features to its content of humus. The humus may be incorporated or unincorporated in the mineral soil. See *Mor; Mull; Litter.*

Humus, Raw—See Mor.

Hurdle System—A method of handling livestock by use of hurdles, or movable fences, making it possible to change the area of immediate use daily or at frequent intervals.

Hydraulic Fill Dam — A dam composed of earth material, pumped into place with water; generally the fines are washed toward the center for greater imperviousness.

Hydraulic Grade Line—In a closed conduit a line joining the elevations to which water could stand in risers or vertical pipes connected to the conduit at their lower end and open at their upper end. In open channel flow, the Hydraulic Grade Line is the free water surface.

Hydraulic Gradient—The slope of the hydraulic grade line. The slope of the free surface of water flowing in an open channel.

Hydraulic Radius — The cross-sectional area of a stream divided by its wetted perimeter. The "r" in Manning's formula.

Hydrograph—A graph showing the stage (depth), flow, and velocity of a stream of water over a period of time. Contrast with *Pluviagraph.*

Hydrologic Cycle—The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes as precipitation, interception, run-off, infiltration, percolation, storage, evaporation, and transpiration.

Hygroscopic Coefficient ***(Soils)***—The moisture, in percentage dry weight, that a dry soil will absorb in a nearly saturated atmosphere (98% relative humidity at 25°C or 77°F).

Hygroscopic Water ***(Soils)*** — Water which is so tightly held by the attraction of soil particles that it cannot be removed except as a gas, by raising the temperature above the boiling point of water. This water is unavailable to plants.

I

Igneous Rock—Rock which has been cooled from molten mineral material; examples, granite, syenite, diorite, and gabbro.

Illuviation—The accumulation of material in a soil horizon by precipitation from downward or lateral movement in solution or to a lesser extent in suspension. Contrast with *Eluviation.*

Impervious Soil—A soil resistant to penetration by water and usually by air and roots.

Improvement Cutting ***(Forestry)***—A cutting made for the primary purpose of improving a stand of trees. Undesirable species, trees of poor form and those that are diseased, or a source of insect infestation are removed so as to improve on quality and vigor of the stand. Also see *Thinning.*

Increment ***(Forestry)*** — The increase in diameter, basal area, height, volume, quality, or value of a tree or stand.

Indicator Plants—Plants which give reliable information concerning present conditions and past history of an area as to soil, alkalinity, salinity, cli-

mate, depth of water table, over-grazing, fires, and the use to which land is best adapted.

Indurated Soil—Soil cemented into a hard mass that will not soften on wetting. See *Hardpan*.

Infiltration—The downward entry of water into soil or other material. Contrasted with *Percolation*.

Infiltration Capacity—The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration Diversion—Diversion of water from a stream by means of perforated pipes or other pervious conduits laid under the streambed.

Infiltration Index—Rate of infiltration calculated from records of rainfall and run-off. There are several different indices each calculated by a different method. A common index, "ϕ", is the average rainfall intensity for a given storm above which the mass of rainfall equals the mass of run-off.

Infiltration Rate—The rate at which water is penetrating the surface of the soil at any given instant, usually expressed in inches per hour. May be limited by either the infiltration capacity of the soil or by the rate at which water is applied to the soil surface.

Infiltrometer—A device for measuring the flow of water into the soil. The water is artificially applied, either by flooding or sprinkling.

Influent—The inflow of water from a channel to subterranean storage. Contrast with *Effluent*.

Inlet ***(Hydraulics)***—(1) A surface connection to a closed drain. (2) A structure at the diversion end of a conduit. (3) The upstream end of any structure through which water may flow.

Intake Area—The area in which an aquifer outcrops and in which water from precipitation and surface streams enters the aquifer. Syn. *Recharge Area*.

Intensity—See Rainfall Intensity.

Intensive Cropping—Maximum use of the land by means of frequent succession of harvested crops.

Interception ***(Hydraulics)*** — The process by which precipitation is caught and held by foliage, twigs and branches of trees, shrubs, and other vegetation. Often used for "interception loss," or the amount of water evaporated from the precipitation intercepted.

Interception Channel—A channel excavated at the top of earth cuts, or at the foot of slopes, or at other critical places to intercept surface flow; a catch drain. Syn. *Interception Ditch*.

Intermediate Water ***(Hydraulics)*** — Water in the zone of aeration betwene fringe and soil water.

Intermittent Grazing—Alternate grazing and resting a pasture or range for variable periods of time. See Rotation Grazing.

Intermittent Stream — A stream or portion of a stream which flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources.

Interplanting — In woodland, the setting out of young trees among existing trees or brushy growth. In orchards, the planting of farm crops among the trees, especially while the trees are too small to occupy the land completely. In cropland, the planting of several crops together on the same land; for example, the planting of beans with corn.

Interspersion ***(Wildlife)***—The distribution and heterogeneous occurrence of cover types and plant species for animal cover in a limited area.

Interstices—The pore-space or voids in the soil and rock of the lithosphere.

Invasion ***(Plant Ecology)***—The movement of plants from one area to another. The process is divided into migration, establishment and finally competition.

Irrigable Area.—The area under an irrigation system capable of being irrigated principally as regards quality and elevation of land.

Irrigation—The application of water to soil to assist in the production of crops. See *Basin Irrigation; Border Irrigation; Check Irrigation; Furrow Irrigation; Sprinkler Irrigation; Square Check Irrigation; Subirrigation; Subsurface Irrigation; Supplemental Irrigation; Winter Irrigation.*

Irrigation District — A cooperative, self-governing public corporation set up as a subdivision of the state, with definite geographic boundaries, organized to obtain and distribute water for irrigation of lands within the district. Other characteristics include creation under authority of the state legislature with the consent of a designated fraction of the landowners or citizens, and taxing power.

Irrigation Lateral—A branch of the main canal conveying water to the farm ditches.

Irrigation Requirement — The quantity of water, exclusive of precipitation, that is required for crop production. It includes economically unavoidable wastes. See *Consumptive Use; Conveyance Loss; Gross Duty of Water; Operation Waste.*

Irrigation Structure—Any structure or device necessary for the proper conveyance, control, measurement or application of irrigation water.

Isolation Transect—A strip of fenced vegetation divided into rectangular plots, one of which may be successively opened or closed to grazing.

J

Jetty—A dike built of piles, rock, or other material, extending into a stream or into the sea at the mouth of a river to induce scouring or bank building, or for protection. See *Spur Dike*.

K

Key Species ***(Range)***—Any forage species which because of palatability, abundance or other factors may be used for significant observations in estimat-

ing utilization, deterioration, trend or condition of the range.

Kutters Formula—An empirical formula for the flow of water expressing the value of the coefficient, C, in the Chezy formula, in terms of the friction slope, hydraulic radius, and a coefficient of roughness.

L

Lacustrine Deposit—Materials deposited in lake water and exposed by lowering of the water level or elevation of the land.

Lagtime—The interval of time between beginning of rainfall excess and peak or maximum rate of runoff for a particular storm.

Lambing Range—The area used during the lambing season by drop and wet bands of sheep. Syn. *Lambing Ground.*

Laminar Flow ***(Hydraulics)***—A type of flow in which each particle moves in a direct parallel to every other particle, and in which the head loss is approximately proportional to the first power of the velocity. Syn. *Streamline Flow; Viscous Flow.*

Laminar Velocity ***(Hydraulics)***—That velocity below which, in a particular conduit, laminary flow will always exist, and above which the flow may be either laminar or turbulent depending on circumstances.

Land—The solid part of the earth's surface and its physical environment, including water supply, temperature and light. Characteristics of Land include the surface configuration, the steepness, length, and direction of slope, numerous soil factors, underground water, and climatic factors such as temperature, precipitation, sunshine, humidity, and wind. Soil conservationists ordinarily consider also as Land those areas of shallow water in which either trees or marsh vegetation grow with their roots in the earth and their leaves above water.

Note: Economists have defined land as the total natural and cultural environment in which production must take place. Land in this sense includes man-made improvements and also the location with respect to centers of commerce and population. Some also consider as land certain areas of water, such as oyster beds and fishing places. It is often convenient to regard land as synonymous with all that nature supplies, external to man, which is valuable, durable, and appropriable, thus including, for example, waterfalls and other sources of waterpower.

Land-Capability—The suitability of land for use without damage. Land Capability as ordinarily used in the United States of America, is an expression of the effect of physical land conditions, includland damage from erosion or other causes, and (b) ing climate, on the total suitability for use without damage for crops that require regular tillage, for grazing, for woodland, and for wildlife. Land-Capability involves consideration of (a) the risks of the difficulties in land use owing to physical land characteristics including climate.

Land-Capability Class—One of the eight classes of land in the land-capability classification. These eight land-capability classes, distinguished according to the risk of land damage or the difficulty of land use, are:

Land suitable for cultivation and other uses

I. (Light green on maps) Very good land for cultivation. Nearly level and productive; not subject to erosion. Needs only ordinary good farming methods.

II. (Yellow) Good land for cultivation. Mostly gently sloping, not more than moderately subject to erosion. Some rather wet. Can be farmed safely with easily applied practices.

III. (Red) Moderately good land for cultivation. Mostly moderately sloping. Some too wet or too dry. Can be farmed safely with practical conservation measures, carefully applied. Usually a combination of two or more measures is needed.

IV. (Blue) Fairly good land, suitable for occasional cultivation. Generally strongly sloping; often shallow or very sandy. Often dry climate.

Land not suitable for cultivation

V. (Dark green) Land very well uited for grazing or forestry. Requires good range or woodland management.

VI. (Orange) Land well suited for grazing or forestry. Steeply sloping land, stony or shallow soil, eroded land, droughty land, or wet land. Requires careful management.

VII. (Brown) Land fairly well suited for grazing or forestry. Severely limited in use by such factors as very steep slope, shallow or droughty soil, wetness, severe erosion, or excessive salinity. Requires very careful management.

VIII. (Purple) Land not suitable for cultivation, grazing, or forestry. May be useful for wildlife, recreation, or protection of water supplies.

Land-Capability Classification—A grouping of the mapping units of a soil conservation survey into land-capability units, subclasses, classes and general divisions.

Land-Capability Map—A map showing land-capability units, subclasses, and classes; or a soil conservation survey map colored to show land-capability classes.

Land-Capability Subclass—A subdivision of a land-capability class according to the kind of difficulty or risk that is involved in using the land. The four subclasses are: e—dominant limitation is susceptibility to erosion, by either water or wind; w—dominant limitation is excess water, such as that produced by seepage, high water table, or floods;

s—dominant limitation is an outstandingly unfavorable soil characteristic, such as low moisture capacity, excess gravel or stone, shallow effective depth; c—dominant limitation is climate, chiefly extremes in precipitation or temperature. Subclasses are not recognized in land-capability class I. The subclass e does not occur in class V.

Land-Capability Unit—A Land-Capability Unit consists of land that is sufficiently uniform in climate, soil, slope, erosion, and other permanent land characteristics to have continuing limitations or hazards of similar degree and nature, and similar inherent potentialities. Thus, the land in a Land-Capability Unit is sufficiently uniform (a) to permit use of the same crops and cropping systems on land suitable for cultivation; (b) to result in a particular climax vegetation (range site); or (c) to result in a given composition and volume of tree crops.

Landslide—The rapid down hill movement of a mass of soil and loose rock usually under wet or saturated conditions. The speed and distance of movement as well as the amount of soil and rock material involved vary greatly.

Land-Use Planning—The development of plans for the uses of land that will, over a long period, best serve the general welfare, together with the formulation of ways and means of achieving such uses.

Lateral-Flow Spillway—A spillway in which the initial and final flow are approximately at right angles to each other; a side-channel spillway.

Leached Soil—A soil from which most of the soluble constituents have been removed throughout the entire profile or removed from one part of the profile and accumulated in another part.

Leaching—The removal of soluble constituents from soils or other material by percolating water.

Leafmold—See Humus Layer.

Legume—A member of the legume or pulse family, *Leguminosae*. One of the most important and widely distributed plant families. The fruit is a "legume," or pod that opens along two sutures when ripe. Flowers are usually papilionaceous (butterfly-like). Leaves are alternate, have stipules, and are usually compound. Includes many valuable food and forage species, such as the peas, beans, peanuts, clovers, alfalfas, sweet clovers, lespedezas, vetches, and kudzu. Practically all legumes are nitrogen-fixing plants, and many of the herbaceous species are used as cover and green manure crops. (Even legumes without feed or forage value, such as crotalaria and some lupines, are used for soil improvement.) The legume family contains timber trees such as locust, honey locust, and many tropical trees, and in addition, ornamental plants, including redbud, mimosa and wisteria.

Legume Inoculation—The addition of the proper strain of nitrogen-fixing bacteria to legume seed or to the soil in which the seed is to be planted. May be accomplished by (1) the addition of bacteria from pure cultures; (2) the addition of soil from a field on which the particular legume species has recently grown successfully. Inoculation is done so that the legume, with the aid of the associated bacteria, can fix nitrogen from the air instead of taking it from the soil.

Length-of-Run ***(Irrigation)***—The distance through which water is carried in furrows or by flooding from the head ditch.

Level Terrace—A terrace that follows the absolute contour, as contrasted with a graded terrace. Used only on permeable soils where conservation of moisture for crop use is particularly important or where outlet channels are impractical.

Lining ***(Hydraulics)***—A protective covering over all or part of the perimeter of a reservoir or a conduit to prevent seepage losses, withstand pressure, resist erosion, and reduce friction or otherwise improve conditions of flow.

Light Soil—See Coarse Textured Soil.

Lime—Lime from the strictly chemical standpoint refers to only one compound, namely calcium oxide (CaO). However, the term Lime is commonly used in agriculture to include a great variety of materials which are usually composed of the oxide, hydroxide, or carbonate of calcium, or of calcium and magnesium. The most commonly used forms of agricultural lime are ground limestone (carbonates), hydrated lime (hydroxides), burnt lime (oxides), marl and oyster shells.

Liming—The application of lime to land, primarily to reduce soil acidity and to supply calcium for plant growth. (Dolomitic limestone supplies both calcium and magnesium.) May also improve soil structure, organic matter content, and nitrogen content of the soil by encouraging the growth of legumes and soil micro-organisms. Liming an acid soil to a pH value of about 6.5 is desirable for maintaining a high degree of availability of most of the nutrient elements required by plants.

Line Plot Survey—A survey employing plots as sampling units. Plots of specified size are laid out, usually at regular intervals along parallel survey lines.

Lip—Part of a dam; a small wall on downstream end of apron, to break the flow from the apron.

Lister—A double plow, the shares of which throw the soil in opposite directions, leaving the field with a series of alternate ridges and furrows. Row crops may be seeded in the bottoms of the furrows as they are opened up; when no seed is planted, the operation is sometimes referred to as *Blank Listing*.
A modification, the *Basin Lister*, has an attachment which forms earth dams across the lister furrows at intervals of 15 to 25 feet, leaving basins with a large water capacity.

Litter ***(Forestry)***—A surface layer of loose organic

debris in forests. It consists of freshly fallen or slightly decomposed organic materials.

Livestock—Domestic animals produced or kept primarily for farm, ranch, or market purposes, including beef and dairy cattle, hogs, sheep, goats and horses. May be subdivided by class of use, purpose, or age as breeding cows, steers, ewes and drys; by kind (species or genus) as cattle, horses, mules, sheep, goats or swine; by type of productive purposes or characteristic qualities as wool or mutton type of sheep.

Loam—(1) Soil containing a relatively even mixture of sand and silt and a somewhat smaller proportion of clay. Generally a sort of desirable quality. May be subdivided into texture classes like sandy loam, loam, silt loam and clay loam. (2) Specifically, soil material containing 7 to 27 per cent clay, 28 to 50 per cent silt, and less than 52 per cent sand.

Loess—Deposit of wind-transported fine textured material, uniform and unstratified, mostly silt, but may contain some fine sand and clay.

Log Chute—A by-pass around or through a dam for logs and drift. Syn. *Log-Way*.

Loose Rock Dam—A dam built of rock without the use of mortar; a rubble dam. See *Rock-Fill Dam*.

Lost Head ***(Hydraulics)***—A measure of the energy expended by flowing water in overcoming resistances to its motion.

M

Mangum Terrace—A type of broad-base terrace first constructed and used in Franklin County, N. C., in 1885. See *Broad-Base Terrace; Ridge Terrace*.

Manning Formula ***(Hydraulics)***—A formula used to predict the velocity of flow of water in an open channel.

$$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n},$$

where V is the mean velocity of flow in feet per second; r is the hydraulic radius; s is the slope of the energy gradient or for assumed uniform flow the slope of the channel in feet per foot; and n is the roughness coefficient or retardence factor of the channel lining.

Manure—(1) Refuse from stables and barnyards consisting of animal excreta with or without straw and other litter. The dung of livestock, birds, and other animals. Also referred to as barnyard manure. (The usual meaning of the term as used in the United States.) (2) Any material which fertilizes land; a fertilizer of either organic or inorganic origin. (Term is seldom used in this broad sense in the United States, but is frequently so used elsewhere.)

Marine Deposit—Materials deposited in the waters of oceans and seas and exposed by elevation of the land or the lowering of the water level.

Marking Trees—Selection and indication, usually by blaze or paint spot, of trees to be cut or those to be retained in a cutting operation.

Marl—An earthy unconsolidated deposit formed in fresh water lakes and consisting chiefly of calcium carbonate mixed with clay or other impurities in varying proportions.

Marsh—Flat, wet, treeless areas usually covered by standing water and supporting a native growth of coarse grasses, reeds, sedges or rushes.

Marsh Management—The development of marshy lands to produce or encourage furbearers, waterfowl, frogs and other wildlife. Measures used may include ditching, control of water level and undesirable vegetation, control of grazing and fire, and plantings for food and cover.

Masonry Dam—A dam built of rock and mortar.

Mass Diagram—A graphical representation of cumulative quantities, such as the integral of a time-flow curve; an integral curve; each point on the curve is the sum of all preceding quantities considered. The diagram is used extensively in water storage analyses.

Mass Movement—Unit movement of a portion of the land surface as in creep, landslide or slip.

Mast—Nuts collectively, as acorns, beechnuts, chestnuts especially as food for animals.

Mattress ***(Engineering)***—A blanket of brush or poles, interwoven or otherwise lashed together and placed to cover an area subject to scour, weighted with rock, concrete blocks, or otherwise held in place.

Meadow—A field in which biennial or perennial crops are grown for hay.

Meadow Strip—A sloping field or strip of grassed land which, in addition to yielding a hay crop, acts as a broad shallow water channel during periods of run-off. Often used as a terrace outlet channel and usually much larger in extent than a grassed waterway.

Mean ***(Statistics)***—The average of a group of items obtained by adding together all items and dividing by the total number of items used.

Mean Depth ***(Hydraulics)***—The cross-sectional area of a stream divided by its surface width.

Mean Velocity ***(Hydraulics)***—The velocity at a given section of a stream obtained by dividing the discharge of the stream by the cross-sectional area at that section.

Measuring Weir ***(Hydraulics)***—A weir especially designed to measure the flow of water in a stream. Some types of measuring weirs are designated by the shape of the notch such as parabolic, rectangular, trapezoidal, triangular, and V-notched. See *Broad-Crested Weir; Cipoletti Weir; Free Weir;*

Sharp Crested Weir; Submerged Weir; Suppressed Weir.

Mechanical Analysis *(Soils)*—(1) The percentage distribution of the various sizes of individual mineral particles, or separates in the soil. (2) A laboratory method of determining soil texture.

Mechanical Control—See Engineering Practices.

Median *(Statistics)*—The value of the middle item when the items are arranged according to size.

Medium Textured Soil—A loamy soil.

Merchantable *(Forestry)*—The portion of trees or stands which can be marketed under given economic conditions. Merchantable length pertains to the marketable length of log in a tree. Merchantable volume pertains to the marketable volume.

Metamorphic Rock—A rock that has been greatly altered from its original condition. Heat, pressure and water are the chief agents in producing metamorphic rock. Igneous and sedimentary rocks may be changed to metamorphic rock or one metamorphic rock may be changed into another. Examples, gneiss, schist, and slate.

Microclimate—Local climatic conditions, brought about by the modification of general climatic conditions by local differences in elevation and exposure.

Microrelief — Minor surface configurations of the land.

Mineral Soil—Soil composed mainly of inorganic (mineral) material with relatively low content of organic material. Its volume weight is greater than that of organic soil.

Miners Inch—The discharge from an orifice 1 inch square under a definite head. It is a rate of flow. The value of a miners inch in cubic feet per second has been fixed by statute in various states.

Minor Element *(Plant Nutrition)*—See Essential Element.

Minor Watershed—Part of a subwatershed which may be selected as a suitable area for detailed planning and application of soil and water conservation measures in cooperation with relatively small local groups of landowners and operators, or local agencies such as drainage districts or municipalities. *See Watershed (2)*

Mixed Forest—A forest composed of trees of two or more species. In practice, usually a forest in which at least 20% are trees of other than the leading species. Contrast with *Pure Forest.*

Mode *(Statistics)*—The most frequent or most common value, provided that a sufficiently large number of items are available to give a smooth distribution.

Moisture Equivalent *(Soils)*—The percentage moisture retained by a small sample of saturated soil after being subjected to a centrifugal force of 1,000 times gravity for a definite period of time, usually ½ hour. A rapid measure of the moisture-retaining ability of the soil; for medium textured soils it corresponds closely to the field capacity. Usually lower than the field capacity for sands and higher than field capacity for soils high in colloidal material.

Mole Drainage—The method of draining land by constructing underground tubular channels in the soil. The channels are constructed with a mole plow consisting of a short pointed cylinder of iron, 4 or 6 inches in diameter, and connected to the beam by a sharp shank about 4 feet long. The plow is pulled along the course of the desired drain with the cylinder at a depth of from 2 to 3 feet.

Mopping-Up *(Mop-Up)*—In Forestry, completely extinguishing a forest fire after it is controlled.

Mor—A type of forest humus layer which consists of relatively pure unincorporated organic matter. It is usually matted or compacted or both and occurs as a distinct layer above the mineral soil. Syn. *Raw Humus.* Contrast with *Mull.*

Mottled *(Soils)*—Irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Mound Planting *(Forestry)*—A method of planting on wet ground in which the seeds or young trees are planted on mounds, ridges, or hills. Syn. *Hill Planting; Ridge Planting.*

Movable Dam — A barrier that may be opened in whole or in part. The movable part may consist of gates, stop logs, needles, wickets, or any other device whereby the area for flow of water through or over the dam may be controlled.

Mowing of Grazing Land — The cutting of top growth of weeds and rankly growing plants on pasture or range land to reduce the competition of plants having little or no forage value with the useful forage plants, and to reduce the interference of useless plants with grazing livestock.

Muck—(1) An organic soil consisting of fairly well decomposed organic material relatively high in mineral content, finely divided and dark in color.

Mudflow — Flow of a torrent so heavily charged with earth and debris that the mass is thick and viscous. Rocks several feet in diameter may be carried in it. Mudflows may result from run-off of very heavy rains or from explosive volcanic eruptions.

Mulch—A natural or artificially applied layer of plant residue or other material such as stones, sand, paper, or brush on the surface of the soil. Also see *Dust Mulch; Mulch Tillage; Self-Mulching Soil.*

Mulch Tillage — Tillage or preparation of soil in such a way that plant residues are left on the surface.

Mull—A type of forest humus layer which consists of thoroughly mixed organic and mineral matter. This layer grades into the underlying mineral horizon without a sharp line of demarkation. Contrast with *Mor.*

Multiple-Arch Dam—A barrier consisting of a series of arches supported by buttresses or piers. The load is transferred by the several arches to the foundation through the buttresses.

N

Nappe ***(Hydraulics)***—A sheet or curtain of water overflowing a structure like a weir or a dam. The Nappe has an upper and lower surface.

Narrow-Base Terrace—A terrace similar to a broad-base terrace in all respects excepting the width of ridge and channel; the base width of a narrow terrace is usually 4 to 8 feet. See *Broad-Base Terrace; Ridge Terrace.*

National Forest—A forest area, usually in hilly or mountainous land, owned by the Federal Government and used for watershed protection, timber production, recreation, and in some areas, limited grazing of livestock.

National Monument—An area owned by the Federal Government for the purpose of preserving and making available to the public a resource of archaelogical, scientific, or aesthetic interest.

National Park— An area of unusual scenic or historic interest owned by the Federal Government and set aside primarily for recreational use. The scenery, the historic objects, and the wildlife are conserved in such a manner that they will be unimpaired for the enjoyment of future generations. Logging, grazing by livestock, and hunting are prohibited. Regulated fishing is permitted in certain areas.

Needle ***(Hydraulics)***—A timber set on end to close an opening for the control of water; it may be either vertical or inclined; a form of stop-plank or log.

Net Duty of Water—The amount of water delivered to the land to produce a crop, measured at the point of delivery to the field. Contrast with *Gross Duty of Water.*

Neutral Soil—Strictly speaking, a soil having a pH value of 7.0. In practice, a soil having a pH value between 6.6 and 7.3.

Niche ***(Wildlife)***—The place in the plant and animal community that a species may occupy.

Nichols Terrace—A small terrace with a comparatively deep narrow channel, and a low flat ridge having a gentle slope on the downhill side. See *Ridge Terrace.*

Nitrification ***(Soils)***—Biological oxidation of ammonium salts to nitrates. This is accomplished by micro-organisms.

Nitrogen Fixation ***(Soils)***—The assimilation of free nitrogen from the air by organisms in the soil so that this nitrogen eventually becomes available to plants.

Nitrogen-Fixing Plant—A plant which can assimilate and fix the free nitrogen of the atmosphere by the aid of bacteria living in the root nodules. Legumes with the associated rhizobium bacteria in the root nodules are the most important nitrogen-fixing plants.

Nodule—A structure developed on the roots of most legumes and a few other plants in response to the stimulus of root nodule bacteria. Legumes bearing these nodules are nitrogen-fixing plants, utilizing atmospheric nitrogen instead of depending on nitrogen compounds in the soil.

Non-Uniform Flow ***(Hydraulics)***—A flow in which the mean velocity is changing along the length of the channel. If the rate of flow is constant it is called *Steady Non-uniform*, otherwise *Unsteady Non-uniform.*

Normal—A mean or average value established from a series of observations for purposes of comparison; for example, normal precipitation, normal temperature, normal flow.

Normal Erosion—The erosion which takes place on the land surface in its natural environment undisturbed by human activity. It includes (1) rock erosion, or erosion of rocks on which there is little or no developed soil, as in stream channels and rocky mountains, and (2) normal soil erosion, or the erosion of the soil under its natural condition or native vegetative cover undisturbed by human activity. Syn. *Geologic Erosion.*

Normal Forest—A standard with which to compare an actual forest to bring out its deficiencies for sustained yield management; the conception of an ideally managed forest; a forest with normal increment, normal age classes in size, distribution, and normal stock.

Normal Soil Erosion—See Normal Erosion.

Notch—The opening in a dam or spillway for the passage of water.

Nurse Crop—See Companion Crop.

Nurse Tree—A tree which protects or fosters the growth of another in youth.

Nursery ***(Plants)***—A place where plants like trees, planting or for use as stocks for grafting; a plantation of young trees or other plants, the young plants being called *Nursery Stock* or *Planting Stock.*

Nutritive Ratio—The ratio or proportion between digestible protein and digestible non-nitrogenous nutrients (carbohydrates and fats) in a livestock feed.

O

Odd Area ***(Wildlife)***—Small areas of land on farms and ranches such as bare knobs, fence corners, sink holes, blow-outs, borrow pits, and irregularly shaped areas that are best used to produce wildlife.

Odd Areas Management—Development, protection and utilization of vegetation on odd portions of farms and ranches for the benefit of wildlife species.

Open Range—An extensive grazing area on which the movement of livestock is free and unrestricted.

Operation Waste *(Irrigation)* — The water wasted through spillways or otherwise discarded from an irrigation system after having been diverted into it.

Organic Matter — A general term for plant and animal material in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that have already passed through the stage of rapid decomposition. Also see *Humus*.

Organic Soil—A soil composed mainly of organic matter on a volume basis. (Twenty percent or more organic matter by weight.) See *Muck; Peat*.

Outfall—The point where water is discharged from a conduit; the mouth of drains and sewers.

Outlet Channel—A waterway constructed or altered primarily to carry water from man-made structures such as terraces, tile lines and diversions.

Overfall Dam—A dam constructed to allow water to overflow its crest.

Overgrazing—Grazing so heavy as to impair future forage production and cause deterioration through damage to plants or soil or to both. It may be general, over most or all the range or pasture area, or local, confined to small areas where livestock congregate, such as around watering places. Contrast with *Undergrazing*.

Overnight Pond *(Irrigation)* — A small regulatory pond primarily to build up a supply of water for release when required to augment the head of water normally available in the farm irrigation ditch.

Overstocked—(1) In forestry, applies to stands with an excessive number of trees that may retard normal growth. (2) In wildlife, a population of animals in excess of the carrying capacity of their habitat.

Overstocking *(Range Management)*—The placing of more animals on a range area than the range will support or maintain through the grazing period without overgrazing. Contrast with *Proper Stocking; Understocking*.

Overstory—The portion of the trees in a forest stand forming the upper crown cover. Syn. *Overwood*. Contrast with *Understory*.

Over-Utilization *(Range Management)* — Excessive use of plants to the extent they become injured, or of pastures and ranges, or parts of both, to the extent they deteriorate.

P

Palatability—The relative relish with which feed and forage is consumed by domestic livestock or other animals. Depends on such factors as the kind of plants, their stage of maturity, and climatic and soil conditions under which the plants grew. Different kinds of livestock vary in their likes and dislikes.

Panel Plot—A small area protected from grazing during a part of the growing or grazing season by a movable fence. Syn. *Hurdle Plot; Panel*.

Parasite *(Botany)*—A plant which grows on and derives its nourishment from another living plant; example, dodder. Contrast with *Saprophyte*.

Parent Material *(Soils)*—The horizon of weathered rock or partly weathered soil material from which the soil is formed. Horizon C of the soil profile.

Parent Rock *(Soils)*—The rock from which parent materials of soils are formed.

Parshall Measuring Flume—A calibrated device for measuring the flow of water in open conduits. It consists essentially of a contracting length, a throat, and an expanding length. At the throat is a sill over which the water is intended to flow at Belanger's critical depth. The upper head is measured a definite distance upstream and the lower head a definite distance downstream from the sill. The lower head need not be observed, except where the sill is submerged more than about 67 per cent. Formerly termed the *Improved Venturi Flume*.

Partial-Duration Series—The tabulation or graph in order of decreasing magnitude of all peak flood discharges above a selected base, frequently equal to the lowest annual maximum peak. In contrast, the *Annual Flood Peak Series* is a graph or tabulation in which only the maximum peak for each year is included in the series.

Pasture—(1) The food of livestock harvested by grazing. (2) An area devoted to the production of forage which will be harvested by grazing animals. Includes natural or native pastures, with native or naturally distributed forage plants on uncultivated land, and pastures seeded by man on cultivated land. Use of the term Pasture is sometimes restricted to parts of farms or relatively limited areas used for grazing, usually privately owned, in humid, subhumid, or irrigated areas. Contrast with *Browse; Brush Pasture; Range*. See *Permanent Pasture; Rotation Pasture; Supplemental Pasture; Temporary Pasture*.

Pasture, Native—Uncultivated land occupied wholly or chiefly by native plants suitable for grazing. Syn. *Natural Pasture*.

Pasture Improvement — Any practice of grazing, mowing, fertilizing, liming, seeding, scattering droppings, contour furrowing, or other methods of management designed to improve the vegetation for grazing purposes.

Pasture Management—The application of practices to keep pasture plants growing actively over as long a period as possible so that they will provide palatable feed of high nutritive value; to encourage the growth of desirable grasses and le-

gumes, while crowding out weeds, brush, and inferior grasses. See *Pasture Improvement.*

Peat—Soil material consisting primarily of raw undecayed or slightly decomposed organic matter.

Perched Water—The body of free ground water in a zone of saturation separated by unsaturated material from an underlying body of ground water in a different zone of saturation.

Percolation—The downward movement of water through the soil, especially the downward flow of water in saturated or nearly saturated soil. Contrast with *Infiltration.*

Perennial Plant—A plant which normally lives for 3 or more years. Contrast with *Annual Plant; Biennial Plant.*

Permanent Pasture—Grazing land occupied by perennial pasture plants or by self-seeding annuals, usually both, which remains unplowed for many years. Contrast with *Rotation Pasture.*

Permeability, Soil—The quality or state of a soil or of any horizon in the soil profile relating to the transmittal of water or air to all parts of the mass.

Permissible Velocity ***(Hydraulics)***—The highest velocity at which water may be carried safely in a channel or other conduit. The highest velocity that can exist through a substantial length of a conduit and not cause scour of the channel. Syn. *Safe Velocity.*

pH—A numerical measure of the acidity, or hydrogen ion activity of a soil. The neutral point is pH 7.0. All pH values below 7.0 are acid and all above 7.0 are alkaline. A change of one unit in pH value represents a tenfold change in hydrogen-ion concentration. Specifically, the logarithm of the reciprocal of the hydrogen ion concentration. (Represents intensity of acidity, not the total exchangeable hydrogen, or quantity of potential acidity.)

Phosphate or Potash Fixation ***(Soils)***—The process by which available phosphorus or potassium in the soil reacts with definite colloids and becomes unavailable to plants.

Piezometric Surface—The level to which the hydrostatic pressure could raise the water surface of a confined water table in wells penetrating this water table.

Pipe Line, Irrigation—A closed conduit for transportation of irrigation water.

Plant Association ***(Plant Ecology)***—An area of vegetation essentially similar throughout in its general appearance, plant species present, and the proportion of these plant species. Based upon a regional rather than a local climate, it generally extends over wide areas. Examples are the mixed prairie, the beech-maple forests, and the desert plains associations of the United States.

Plant Food—(1) See Plant Nutrients. (2) Strictly speaking Plant Food is the proteins, carbohydrates and fats manufactured within the plant from nutrient elements, but the term is used, particularly by the fertilizer trade, as synonomous with the plant-nutrient elements N-P-K, and the trace elements.

Plant Nutrients—The elements or groups of elements taken in by the plant which are essential to its growth, and used by it in elaboration of its food and tissues. Includes nutrients obtained from fertilizer ingredients. See *Essential Element.*

Plant Residue—See Crop Residue; Humus; Litter; Mor; Mull; Organic Matter.

Plantation, Forest—A stand of trees established by setting out young trees or by sowing seed.

Planting Stock—Young plants, either nursery stock or wildlings, for planting.

Plowpan—A compacted layer formed in the soil immediately below plow depth. A Plowpan is caused by operations such as the sliding action of the plow bottom, or by the trampling of horses or the pressure and vibration of tractor wheels. Syn. *Plowsole.*

Pluviagraph ***(Hydraulics)***—A hypothetical hydrograph prepared to show the stream flow if all precipitation appeared as surface run-off. A graph for showing total rainfall. Contrast with *Hydrograph.*

Point Row—A row which forms an angle with another row instead of paralleling it to the end of the field. A row that "comes to a point," ending part way across the field instead of at the edge of the field.

Pond—See Farm Pond.

Pond Management—Development of suitable measures for the protection of ponds from erosion and siltation, and for uses of ponds such as production of fish and other wildlife, fire protection and stock water. Also see *Fish Pond Management.*

Porosity, Soil—The percentage of the soil (or rock) volume which is not occupied by solid particles, including all pore space filled with air and water. The total porosity may be calculated from the formula:

$$\text{Percent pore space} = 1 - \frac{\text{volume weight}}{\text{specific gravity}} \times 100$$

The total porosity includes both capillary and non-capillary porosity. Capillary porosity refers to the small pores that hold water by capillarity, while the non-capillary porosity refers to the larger pores that will not hold water by capillarity. A soil with low porosity, especially low non-capillary porosity, may be called a "non-porous" or "dense" soil, while a soil with high porosity, especially non-capillary porosity, may be called a "porous" or "open" soil.

(*Continued in July issue*)

If every farmer followed conservation measures recommended by his soil-conservation district for the protection of our natural resources, floods would be rare indeed.

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To encourage proper land use practices, The Goodyear Tire & Rubber Company, Inc., is privileged and pleased to sponsor another series of competitive awards for the Governing Bodies of Soil Conservation Districts and participating farmers.

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